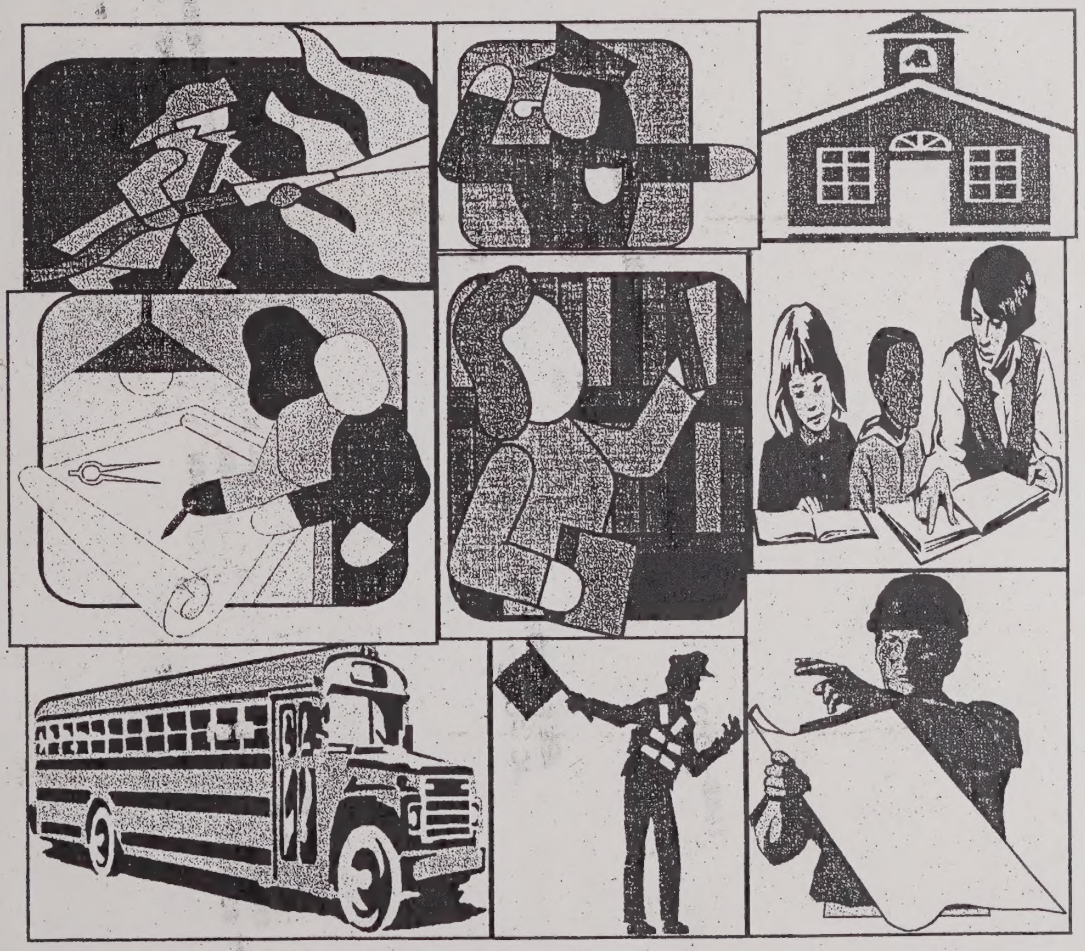
[1997 update]

City of Selma General Plan

Safety, Public Services and Facilities Elements



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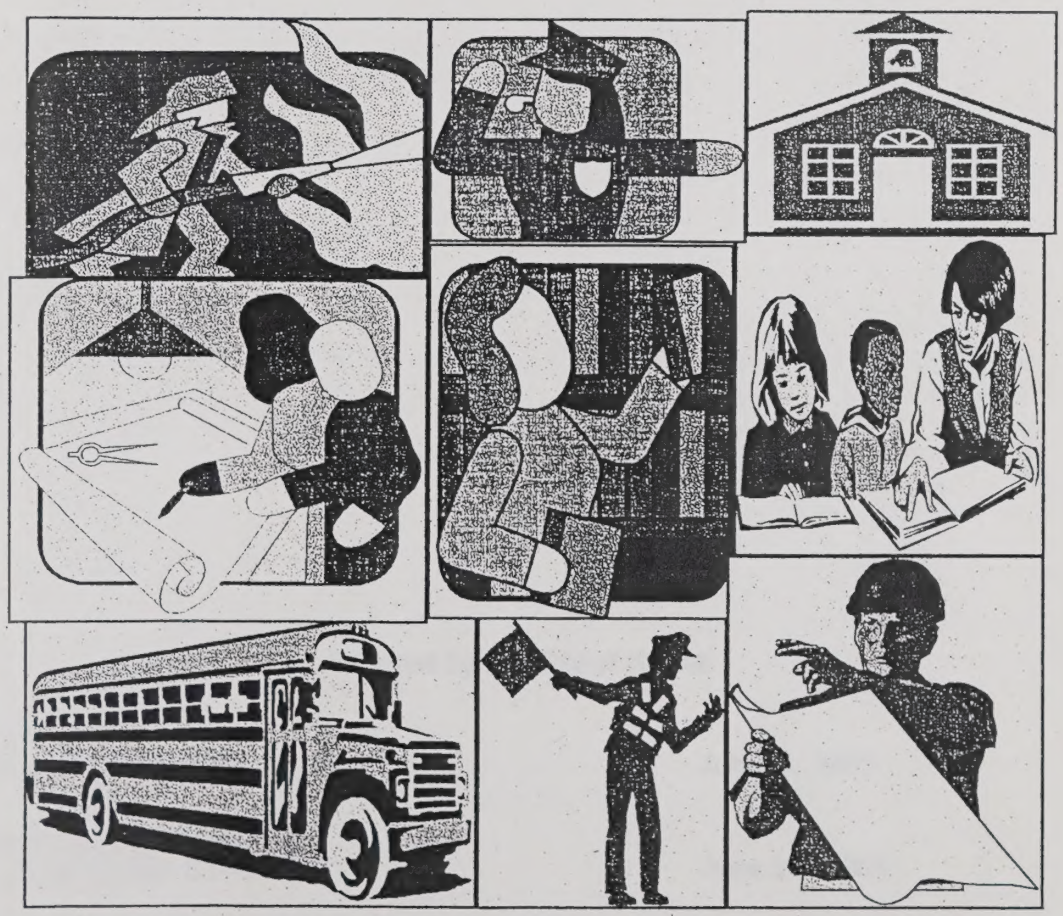
City of Selma General Plan

Safety, Public Services and Facilities Elements



Public Services and Facilities Elements of the Selma General Plan

Adopted by the City of Selma

City Council
Resolution No. 2087 July 18, 1983

Planning Commission
Resolution No. 83-492 June 27, 1983

[1997]

PUBLIC SERVICES AND FACILITIES ELEMENT

Authorized by Government Code Section 65303(e), the Public Services and Facilities Element of the General Plan is an optional Element. Among the optional Elements permitted, only the Recreation Element, which is required to implement in-lieu park fee ordinances, is more common. By statute, the Element may show general plans and policies regarding the provision of sewerage, wastewater treatment, refuse disposal, storm drainage, power and other such facilities. The scope of this Element, however, is limited, due to local conditions and needs, to policies relating to educational facilities, City government facilities, fire and police protection, storm drainage systems, and wastewater treatment and collection facilities.

1.0 GOALS

The following goals are adopted to guide the policies and plans for public services and facilities in the Selma Planning Area:

1.1 provide adequate and convenient school facilities in order to provide an appropriate education for all pupils;

1.2 reduce the threat to persons and property resulting from natural and man-made hazards including fire, crime and flooding;

1.3 provide a safe and sanitary physical environment; and

1.4 undertake required improvements of the sewer and storm drainage systems.

2.0 Existing Conditions and Trends

Data relating to each of the services and facilities subject to this plan are summarized below from the Environmental Assessment: A Background Document for the General Plan and Master EIR.

Schools

The Planning Area is currently serviced by the Selma Unified School District which operates seven elementary schools, two high schools (one of which is a continuation school), and junior high school. Total enrollment in 1981 was estimated to be 4,190. Projected average daily attendance in the 1981-82 fiscal year was 3,622. Total enrollment for the 1981-82 fiscal year was 3,776.

Based on the District's pupil generation factor of 0.733 pupils per household, between 2,000 and 2,500 additional students will be in the Planning Area by 2000 in all grades.

CITY GOVERNMENT FACILITIES

The existing City Hall is located on Tucker Street between Selma and Second Street. Planning, finance and general governmental service administration are located in the facility. Based on space utilization standards for various office uses typical of city governments, it is estimated that there is a need for at least 4,000 square feet of space to accommodate City Hall services.

Fire Protection

There are currently nineteen police officers in the Police Department. The current Police Department staffing is 1.72 officers per 1,000 population.

FLOOD CONTROL AND STORM DRAINAGE

The Selma Planning Area does not have any officially designated flood hazard areas. Local storm water drainage is provided by a network of ponding basins, canals and storm drains. Most of the newer areas of the community are well drained; however, some of the older areas, such as the area bounded by Valley View, Floral, Olive and Thompson Avenues do experience some localized ponding during heavy rain concentrations. The City has recently completed and adopted an Urbanizing Area Master Plan for Storm Drainage as part of the General Plan, Public Facilities Element (1982), which includes plans to eliminate problems in the existing areas of the community, designates adequate facilities for future development, and suggests the joint use of facilities for recreational purposes where feasible.

SEWERAGE AND SEWAGE TREATMENT

The Selma Planning Area is currently served by the Selma-Kingsburg-Fowler County Sanitation District (SKF). Current flow at the plant is ten million gallons per day. Average flow per equivalent residential unit is 420 gallons per day.

3.0 Policies

The following policies are adopted to achieve the goals of this Element:

3.1 new school sites shall be designated on the land use plan in locations convenient to their service populations;

3.2 adequate space and facilities shall be provided for City services and administrative functions;

3.3 the City shall continue to review fire call response time and other factors relating to ISO ratings and strive to maintain the current ISO rating;

3.4 adequate facilities shall be provided for law enforcement and fire suppression and prevention programs;

3.5 police and fire staffing levels shall be reviewed on an annual basis to determine appropriate and feasible staffing ratios;

3.6 capital improvements shall be undertaken to eliminate existing flooding problems;

3.7 the adopted Urbanizing Area Master Plan for Storm Drainage (1981) shall be utilized to determine adequate facilities for new development;

3.8 all new developments shall be required to have community sewer, water and storm water systems;

3.9 develop a civic center complex, including community service facilities, courtroom and fire department headquarters to be located in the vicinity of Jackson School at McCall Avenue and Nelson Boulevard;

3.10 recommend expansion of Wilson and Roosevelt Schools, and provide for continued use for education and recreation at Eric White, Wilson and Roosevelt and Selma High schools.

Safety Element of the Selma General Plan

Adopted by the City of Selma

City Council
Resolution No. 91-16R — February 4, 1991

Planning Commission
Resolution No. 91-740 — January 14,1991

I INTRODUCTION

A. LEGISLATIVE REQUIREMENTS

The Safety Element of the Selma General Plan is adopted to provide for the protection of residents of the Selma Community from natural and man-induced hazards. The Safety Element is prepared pursuant to California Government Code Section 65302 requiring preparation and adoption of a Safety Element by all counties and cities within the state. The code requires:

> "A safety element for the protection of the community from any unreasonable risks associated with the effects of seismic activities, including induced surface rupture, ground shaking, ground failure, tsunami, seiche and dam failure; slope instability leading to mudslides and landslides, subsidence and other geologic hazards known to the legislative body; flooding; and wildfire and urban fires. The safety element shall include mapping of known seismic and other geologic hazards. It shall also address evacuation routes, peak load water supply requirements and minimum road widths and clearances around structures, as those items relate to identified fire and geologic hazards."

B. SCOPE OF THE SAFETY ELEMENT

The Safety Element of the Selma General Plan represents the City of Selma's intent to immediately comply with government requirements for such an element. The plan is an interim document prepared by incorporating new and previously developed and accepted materials, which adequately address the required issues of a safety element and provide the basis for policy adoption.

II OVERALL GOALS OF THE SAFETY ELEMENT

A. SUMMARY

The Safety Element identifies a range of hazards to life and property to which the City of Selma and its residents are subject. The goals for protection of life and property are common to each hazard and are, therefore, presented as the overall goals of the Safety Element. Similarly, emergency services planning is essential to disaster mitigation. Although emergency services planning cannot prevent disasters, it can provide for coordinating public action during the time of disaster to reduce loss of lives and property.

The City of Selma is presently completing an update to the City of Selma Emergency Plan to provide for community safety in the event of a major emergency due to earthquake, flood, fire, nuclear accident, civil disturbance of war. The plan provides the basis for direction and control of emergency operations and continuity of government, saving life and property, repairing and restoring essential systems and services, managing remaining resources and coordinating operations with other jurisdictions.

The Plan contains specific task assignments of various City personnel under emergency conditions including staffing of communications systems, emergency operations centers and shelters. When a disaster occurs, the normal governmental organization converts to an effective agency coping with public health and safety problems created by an emergency.

The location of a number of sites and their priorities as emergency operations centers and Administrative Headquarters, depending on the nature of the incident, established in the Plan.

B. SAFETY ELEMENT GOALS

1. To prevent loss of life and serious injury, resulting from natural or man-induced hazards, to the residents of the City of Selma.

2. To prevent serious structural damage to critical facilities and structures where large numbers of people are expected to congregate at one time.

3. To ensure the continuity of vital services to the Selma area in case of disaster.

4. To provide a leadership role in education on public safety.

III SEISMIC HAZARDS

A. SUMMARY

The Seismic Safety component of the Selma Safety Element maintains as its basis the technical studies, findings and recommendations of the Five County Seismic Safety Study completed for Fresno, Kings, Tulare, Madera and Mariposa Counties in 1975.

The Selma Community is identified by the Five County Seismic Study as being located within the study's category of Seismic Zone V 1. Most of the eastern San Joaquin Valley floor is designated to be in the V 1 Seismic Zone.

The V 1 Seismic Zone is generally characterized as having a thin section of sedimentary rock overlaying a granitic basement. Amplification of shaking that would affect low to medium-rise structures is relatively high, but the distance from any of the faults that are the expected sources of the shaking is sufficiently great that the effects would be minimal. The requirements of Zone 3 of the Uniform Building Code should be adequate for normal facilities.

Seismic events or earthquakes originate as shock waves along an active fault. Active faults considered to be potential hazards to the Selma area, though not located within the five county area, include the San Andreas fault, the Owens Valley fault and the White Wolf fault. In Addition, Fresno County has recently become aware of a bedding plane fault system that is generally located at the border between the central California Coastal range and the San Joaquin Valley. This fault system is complicated by what seismic recordings seem to indicate, that reverse or thrust faulting is occurring at depth. The Coastal Range - San Joaquin Valley bedding plane fault, which is characteristically not visible at surface grade, became evident as a result of seismic activity resulting in the Coalinga disaster in May of 1983.

The Five County Seismic Study identified two types of hazards related to seismic activities: Primary and Secondary Natural Hazards. Primary Natural Hazards resulting from seismic events are ground shaking and the potential for ground rupture along the surface trace of the fault. Since no known faults exist in the Selma area, the only historic Primary Natural Hazards have been ground shaking and not ground rupture. Secondary Natural Hazards result from the interaction of ground shaking with existing ground instabilities, including liquefaction and settlement. Although the potential for Secondary Natural Hazards in the Selma area have been considered minimal, from a historic perspective, the potential for liquefaction and ground settlement instabilities should be evaluated in the seismic safety update process. Other Secondary Natural Hazards, including mudslides, landslides, seiches (waves in lakes) and tsunamis (tidal waves), are not realistic Secondary Natural Hazards for the Selma area due to the city's flat inland terrain on the San Joaquin Valley Floor.

B. SEISMIC SAFETY OBJECTIVES

1. Identify risks to the City of Selma from seismic hazards.

2. Establish and maintain a plan to minimize identified risks from seismic hazards.

3. Establish and maintain a plan for responding to seismic disaster and for the provision of emergency services.

4. To adopt a Seismic Impact Transportation Plan reflecting primary and secondary disaster access routes and designating appropriate evacuation routes.

C. SEISMIC SAFETY POLICIES

1. The safety element shall be reviewed and updated periodically. Upon adoption of the Interim Safety Element, the City should review and update the plan within one year and every five years thereafter.

2. The City shall develop and adopt an Emergency Operations Plan which shall include action plans in the event of an earthquake disaster. Emergency evacuation routes should be included in the plan.

3. The City shall maintain and continue to update, with the County of Fresno and other agencies, an Emergency Services Plan. Included in the plan should be:

   a. Provision for control and direction of emergency operations.

   b. Provision for continuity of governmental services.

   c. Program to coordinate the repair and restoration of essential systems and services.

   d. Coordination of emergency operations with other jurisdictions.

4. The City should establish an inspection program to identify and inventory all existing unreinforced masonry structures in the City.

5. The City should implement a program to abate all identified dangerous buildings.

6. Emergency communication centers, fire stations and other emergency service or critical facilities should be examined to determine earthquake resistance. A program to mitigate deficient facilities should be established.

7. Emergency procedures should be identified for public and private utility districts.

8. Primary and secondary hazards from seismic activity should be evaluated in all environmental assessment and reporting processes.

9. The list of critical facilities for the City of Selma in appendix D, of the Summary and Policy Recommendations of the Five County Seismic Report, shall be reviewed and updated.

10. Critical facilities shall be designed to the standards established by the Uniform Building Code for such facilities. Critical facilities means essential facilities as provided in the Uniform Building Code.

11. The City shall continue to adopt current issues of the Uniform Building Code and implement the seismic design standards provided by the Code.

12. Seismic safety information should be made available to the general public. School districts and agencies related to aged, handicapped and seismically susceptible industries should be encouraged to develop education programs for seismic awareness.

13. The Technical Report of the Five County Seismic Study should be made available to planning projects in the City of Selma.

14. The Seismic Impact Transportation Plan designates the following disaster transportation routes.

    a. PRIMARY TRANSPORTATION ROUTES

        1. FREEWAY 99 through the Selma Planning Area;

        2. Manning Avenue through the Selma Planning Area;

        3. McCall Avenue between Manning Avenue and Second Street;

        4. Second Street between McCall Avenue and Nebraska Avenue;

5. Nebraska Avenue between Second Street and Highland Avenue;

6. Highland Avenue south of Nebraska Avenue.

b. SECONDARY TRANSPORTATION ROUTES

1. Golden State-Whitson through the Selma Planning Area;

2. McCall Avenue south of Golden State-Whitson;

3. Del Rey Avenue between Manning Avenue and Orange Avenue;

4. Orange Avenue (Ditch Road) between Del Rey Avenue and Rose Avenue;

5. Rose Avenue between Orange Avenue and McCall Avenue.

c. EVACUATION ROUTES

All major streets of the Circulation Element of the Selma General Plan, to include arterial and collector streets; shall be designated as evacuation routes in the event of a seismic disaster.

IV GEOLOGIC HAZARDS

A. SUMMARY

The valley lands of eastern Fresno County comprise a cross section of a part of the eastside alluvial plains of the San Joaquin Valley. The alluvial materials that formed the landscape were derived from the highlands of the Sierra Nevada range. Deposition over a long period of time has resulted in differing landforms. The landforms consist of alluvial terraces, young alluvial fans, recent fans and flood plains. The existing land form in the Selma area is typically young alluvial fan of the Kings River.

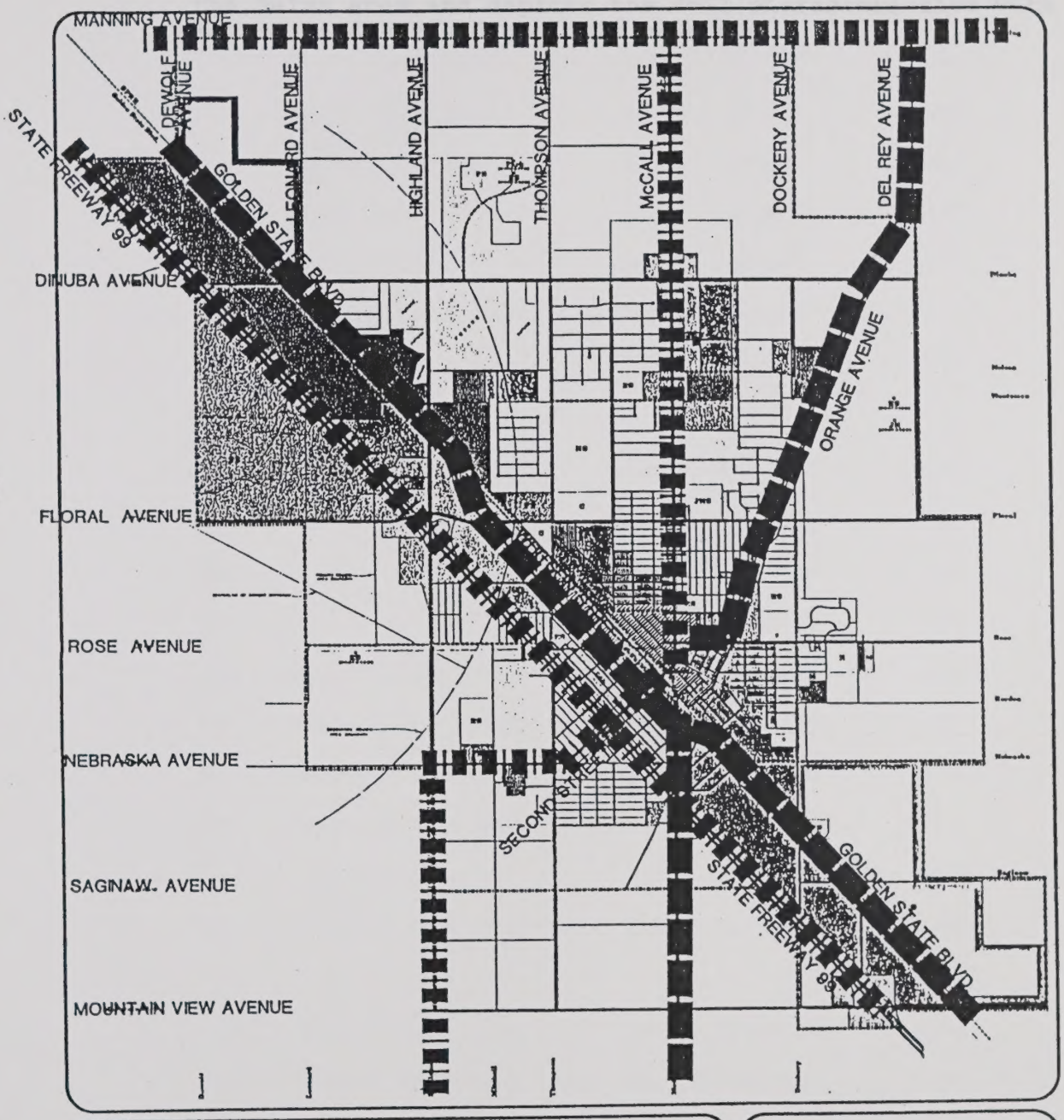
In 1971, the Soil Conservation Service, U.S. Department of Agriculture, completed and published Soil Survey: Eastern Fresno Area. The document classifies soils, provides soil descriptions and locations and identifies limitations associated with specific soils. Geologic

SEISMIC IMPACT TRANSPORTATION PLAN

PRIMARY TRANSPORTATION ROUTE

SECONDARY TRANSPORTATION ROUTE

EVACUATION ROUTES ALL ARTERIAL AND COLLECTOR STREETS



LEGEND:

Agriculture

Residential densities
- low
- medium
- high

Industrial

Golden State Industrial Corridor (Reserve)

Commercial
- neighborhood
- community
- central business
- service
- highway
- residential office

Public
- park
- ponding basin
- school
- medical
- hospital
- cemetery

Circulation
- local collector
- collector
- arterial
- super arterial
- expressway
- freeway
- pathway

SELMA

Land Use and Circulation Plan

1983

NORTH

hazards or limitations that are identified in the report and that could have a bearing on urban structures are: expansive soil characteristics, low soil pressure ratings and corrosivity of soil. The applicability of these soils limitations to the Selma area is discussed below. Table No. 1 identifies all of the soils found in the Selma area and depicts the soil characteristics with regard to described geologic hazards.

TABLE NO. 1
SOIL CHARACTERISTICS
OF THE SELMA AREA

SYMBOL	SOIL NAME	S/S	SOIL PRESSURE	CORROSIVITY
DhA	Delhi Loamy Sand	Low	Severe	Low
DhB	Delhi Loamy Sand	Low	Severe	Low
DlA	Delhi Loamy Sand	Low	Severe	Low
DeA	Delhi Sand	Low	Severe	Low
DeB	Delhi Sand	Low	Severe	Low
Dm	Dello Loamy Sand	Low	Severe	Low
Dn	Dello Sandy Loam	Low	Severe	Low
Hc	Hanford Sandy Loam	Low	Moderate	Low
Hg	Hanford Sandy Loam	Low	Moderate	Low
Hm		Low	Moderate	Low
Ho		Low	Moderate	Low
Hsm	Hesperia Sandy Loam	Low	Moderate	Low
Hso	Hesperia Sandy Loam	Low	Moderate	Low
Hst	Hesperia Fine Sandy Loam	Low	Moderate	Low
Hsy	Hesperia Fine Sandy Loam (saline-alkali)	Low	Moderate	High
Hsr	Hesperia Fine Sandy Loam	Low	Moderate	Low
PmB	Polaski Sandy Loam	Low	Moderate	Low
PmB	Polaski Fine Sandy Loam	Low	Moderate	Low
TzbA	Tujunga Cobbly Loamy Sand	Low	Severe	Low

Expansive soils are those which exhibit shrink-swell characteristics by increasing in volume when wet or reducing in volume when dry. These shrink-swell characteristics have significance as to the suitability of soils for building foundations and construction. Expansive soils can result in building foundation cracking and building distortion. Fortunately, all of the soil series within the Selma area exhibit low potentials for risk related to expansive characteristics.

Soil pressure ratings represent another measure of limitations upon soil for building foundation construction based on "Allowable Soil Pressure" as specified in the California Uniform Building Code, Table 29B. The U.S. Soil Conservation Service, in its publication "Soil Survey, Eastern Fresno Area," rates those Delhi, Dello and Tujunga Series soils found in the Selma area as having potentially severe soil pressure limitations. All other soils are rated as moderate.

With the exception of Hsy (Hesperia fine sandy loam, moderately deep, saline-alkali), all of the soils in the Selma area have a low rating for corrosivity hazards. The ratings for soil corrosivity of soils are listed in Table 1 above, as reported the U.S. Soil Conservation publication Soil Survey, Eastern Fresno Area. The ratings relate to the physical, chemical and biological characteristics and qualities of the soils. Structural material, such as untreated steel pipe, corrodes when buried in soil. The most important characteristics that affect the rate of corrosion, according to the U.S. Soil Conservation Service, are: electrical resistance to the flow of current; total acidity; soil drainage, texture of the subsoil; and, conductivity of the saturation extract.

B. GEOLOGICAL SAFETY OBJECTIVES

1. To provide a safe environment for building construction through knowledge and understanding of soil and land resources.

C. GEOLOGIC SAFETY POLICIES

1. Detailed mapping and analysis of identified areas of geologic hazard shall be provided. Areas identified with a "severe" rating for allowable soil pressures or high corrosivity soil characteristics should be mapped for City staff use in new development project consideration.

2. Continue to enforce the Uniform Building Code in all matters related to soil preparation and foundation requirements.

V FLOOD HAZARDS

A. SUMMARY

The Federal Emergency Management Agency has, in the past, coordinated the preparation of Flood Insurance Rate Maps for all of the cities in Fresno County. The Flood Insurance Rate Maps depict areas that are subject to 100 and 500 year flooding events. Anticipated flooding for such events would characteristically be sheet flooding resulting from protracted rainfall.

Because the City of Selma and its immediate surrounding area have not been historically subject to flooding, it is generally accepted that the City is not at risk from flooding resulting from 100-500 year events.

The City of Selma has adopted a master plan for storm drainage facilities. The plan has been developed with the philosophy that there is little danger to public health from uncontrolled storm water runoff. The exception relates, indirectly, to traffic hazards created by ponding water in the streets. The development of Selma's storm drainage system will serve to offset increased storm water runoff resulting from the additional impervious surfaces imposed by new development. The storm drainage facilities will enhance public safety, prevent property damage and generally improve the appearance of the community.

Information from the U.S. Army Corps of Engineers, State Office of Emergency Services and the County of Fresno indicate that preliminary studies have been conducted to assess the potential hazards of dam failure. The results of the preliminary studies reveal that the City of Selma would be in extreme danger in the event of a complete dam failure of Pine Flat Dam at a time that the facility is at full capacity. In such an event, a worst case scenario, the City of Selma would be located in the center of a floodway approximately seventeen miles wide and eight to ten feet in depth within three hours of the actual failure. No projections of hazard for lesser events have been made, presumably, because of a wide range of circumstances, i.e., water level, degree of dam failure.

Any disaster plan related to the failure of dams in Fresno County is beyond the scope of a single governmental agency. Advance communication of impending or actual failure, as well as, coordinated activities between jurisdictions for further communication, evacuation and emergency services are essential in such an event.

B. FLOOD SAFETY OBJECTIVES

1. Minimize the hazards of localized sheet flooding resulting from prolonged rainfall and storm water runoff.

2. Promote and become instrumental in coordinating the inclusion of a dam failure component to a regional disaster plan.

C. FLOOD SAFETY POLICIES

1. The City of Selma shall evaluate territories within its sphere of influence to identify areas of potential localized flood hazards.

2. In areas identified as being potentially subject to flooding, where the exact area and depth of flooding is uncertain, the applicant or developer of an annexation or development proposal shall be responsible for the preparation of a civil engineering report evaluating the flooding potential.

3. The City of Selma shall continue to implement and administer the Master Plan for Storm Drainage as a means of offsetting increased storm water runoff from urbanization.

4. The City of Selma shall seek and petition the County of Fresno, Council of Fresno County Governments and other agencies and cities impacted by potential dam failure, to participate in the completion of a disaster plan dealing with dam failure.

5. The City shall prepare a local emergency evacuation plan responding to the complete failure of Pine Flat Dam at peak capacity. The evacuation plan shall be coordinated with other responsible and impacted jurisdictions.

VI TRANSPORTATION HAZARDS

A. SUMMARY

Two major transportation arteries of statewide significance traverse the City of Selma. The routes, a main line of Southern Pacific Railroad and State of California Freeway 99, cross the city in a northwest - southeast manner. Land uses along the transportation routes represent the full range of urban type uses. George Washington and Heartland elementary schools are located approximately 200 to 250 feet from Freeway 99.

Major transportation routes are frequently used to transport hazardous materials that could represent a danger to the community if involved in a transportation accident or an improper handling incident.

In addition, two private airports exist with influence upon the City of Selma. The Selma Aerodome is a private airport available for public use. It is located approximately 1½ miles west of the City. An airport Land Use Plan has been adopted by the City of Selma and the Fresno County Airport Land Use Commission. The Airport Land Use Plan establishes policies for air space protection, land use safety, general nuisance and noise policies. The second private airport owned by Quinn Corporation, is located between Freeway 99 and Golden State Boulevard in the northerly portion of the City of Selma. Because the Quinn airport is an entirely private facility with no availability to the general public, it is not subject to the requirements of an airport land use plan. Consequently, safety considerations become the responsibility of Federal Aviation Administration and the local jurisdiction. Since the airport is existing, the City should give air traffic safety issues consideration in any development proposal or land use change request.

B. TRANSPORTATION SAFETY OBJECTIVES

1. To maintain a responsive City staff, trained in Hazardous Materials incidents.

2. To maintain a safe relationship between major transportation routes and urban land uses.

3. To provide for land use safety in areas influenced by airports.

C. TRANSPORTATION SAFETY POLICIES

1. The City shall consider the impacts of potential transportation hazards upon adjacent land uses when considering proposals for new or changed urban uses.

2. New public use buildings, such as, schools and hospitals, should be located a minimum of 1000 feet from mainline rail or freeway routes.

3. The City shall continue to staff, train and equip an emergency response team to respond and coordinate public safety activities. The Selma Fire Department is designated as the City's emergency response team for hazardous materials incidents.

4. The City shall continue to implement the airport land use plan for the Selma Aerodome.

5. New public use buildings should not be located within the flight path or approach zone of airports.

VI FIRE HAZARDS

A. SUMMARY

The protection of a community form fires is discussed as one component of the safety element of the City of Selma General Plan. The State of California General Plan Guidelines indicate that local general plans ought to contain an assessment of the adequacy and reliability of fire protection services. This assessment is to contain an identification and evaluation of water supply and distribution, response time, staff and type of fire fighting equipment and facilities.

Urban-type fires are the most relevant fire hazards for the Selma area. Because of the nature of farming and the small amount of vacant land in the fringe area, there is only a minimal fire hazard or danger of wild fire to the adjacent rural area. Therefore, urban fire suppression is the major subject of this section.

The Selma Fire Department is comprised of 34 personnel, 20 volunteers and 14 full time paid members of which there is 1 Chief, 3 Captains, 5 Engineers, and 5 firefighters. As the fire protection service is within the City of Selma normal response times are very short. Usually, the Fire Department is on the scene to any fire call in its response area in less than five minutes.

Emergency medical services are a large part of the Selma Fire Department's activities. The department operates a paramedic ambulance service that has a first response area of about 175 square miles of Fresno County area around the City of Selma. This area is designated by Fresno County as Ambulance Zone G. The staffing of the ambulance service is done with the fire department

firefighters, engineers and captains of which there are 7 certified as paramedics, 7 full time, and several volunteers certified as Emergency Medical Technicians. In addition to the ambulance response, the fire department also responds an engine company as medical aid first responders to all emergency medical calls within the City of Selma.

The fire protection equipment operated by the City of Selma Fire Department includes a 1985 Gruman pumper with a 1,250 GPM Waterous pump and a 750 gallon water tank, a 1971 Ford Van Pelt pumper with a 1,000 GPM Hale pump and a 750 gallon water tank, and a 1954 GMC - Van Pelt pumper with a 1,000 GPM Hale pump and a 500 gallon water tank.

The City of Selma Fire Department also participates in a mutual aid program with Mid Valley Fire Protection District (the provider of fire protection service to the rural Fresno County area around Selma) providing reciprocal backup services when necessary. In addition, mutual aid assistance is also available from the City of Fresno Fire Department, Kingsburg Volunteer Fire Department and Reedley Volunteer Fire Department. Other fire service resources available for major incidents may be procured through the State Department of Forestry or the Office of Emergency Services.

Currently, the City of Selma has a class 5 insurance rating based on the ten-point scale established by the Insurance Services Office (I.S.O.). Class 1 is the I.S.O.'s highest rating.

The water system for the City of Selma is owned by California Water Service Company. The water wells within the city have adequate capacity to meet normal demand, as well as, emergency situations. The distribution system provides hydrants adequately spaced and with the appropriate water flow throughout most of the response area. Five of the well sites are equipped with auxiliary power to provide water during power failure conditions. In addition, Mid Valley Fire Protection District can provide Water Tender (Tankers) for water supply, when needed, through our mutual aid program.

To cover Hazardous Materials Incidents responses, the City of Selma Fire Department personnel are trained and certified as First Responder Operational staff. In addition, the City of Selma has contracted with the Fresno City Fire Department Hazardous Material Response Team for incidents requiring specialized equipment and training.

The City of Selma operates a fire prevention program that includes an annual inspection of vacant lots and non-residential structures for fire hazards. Vacant lots with vegetation constituting a potential fire hazard are posted and worked by the Public Work Department. The fire department also reviews site plan and business license applications for fire safety considerations, conducts periodic fire prevention public information programs and has an ongoing smoke detector installation program.

In order to implement fire protection measures, the City of Selma has adopted the Uniform Fire Code and Fire Code Standards that set forth how a building is used, how machines and equipment are maintained, how hazardous materials are handled and stored, and how access to and from the site is provided. The Uniform Building Code provides minimum standards for design, construction, materials, use, occupancy, location and maintenance of all buildings within the city. In addition, all new developments are reviewed by city departments for their potential effects on public safety. Further, conditions are attached to minimize those effects and inspections are conducted to ensure proper construction and installation.

B. FIRE SAFETY OBJECTIVES

1. To prevent urban fires through code enforcement and public education.

2. To minimize property damage and public injury through effective fire service delivery.

C. FIRE SAFETY POLICIES

1. The City shall maintain an efficient fire department operation and strive to keep the staffing and equipment levels in line with the growth of the City.

2. The City will strive to reduce the demand for fire service by emphasizing fire prevention and public education. The Selma Fire Department will continue to conduct annual fire prevention inspections for commercial uses.

3. The City will require installation, maintenance and inspection of automatic fire detection and suppression devices in structures as required by City Code.

4. The City will encourage the use of fire detection and suppression devices in other areas where they may provide additional protection of life and property.

5. New development in the City of Selma should conform with existing fire codes, including the provision of adequate ingress and egress for fire response vehicles.

6. The City should continue to monitor the water supply system for fire protection purposes to include the water supply for both peak load and emergency use. Areas of substandard water supply should be identified, and system improvements completed prior to and in conjunction with new development in the area.

7. The City should continue to enforce its weed abatement program limiting the amount of combustible vegetation throughout the plan area.

8. The City should encourage public and private agencies, especially schools and social service groups to become involved in promoting fire protection and prevention education.

VII HAZARDOUS MATERIALS

A. SUMMARY

Hazardous materials have become a part of the everyday living environment of today's society. The use of potentially hazardous materials in significant quantities by businesses and industry constitutes a significant hazard from improper handling or accidents. In addition, society is steadily increasing waste products that potentially results in hazards to the environment.

The California Department of Health is primarily charged with responsibility for hazardous materials. It is responsible for preparation and adoption, with revision as necessary, of a list of hazardous wastes. The Department of Health is also required to adopt minimum standards and regulations for handling, processing, use, storage, disposal and recovery of resources from hazardous wastes to protect public health and the environment.

Fresno County Environmental Health Department is responsible for implementing local level administration of Chapter 6.95 of the California Health and Safety Code. Businesses handling or storing threshold amounts of hazardous materials are required to file a Business Plan with the Health Department. The plan lists annual inventories of hazardous materials, establishes an emergency response program in the event of an accident and requires training of employees handling hazardous materials.

B. HAZARDOUS MATERIALS SAFETY OBJECTIVES

1. To reduce and control the effects of hazardous wastes so as to promote the public health and welfare of the Selma Community.

C. HAZARDOUS MATERIALS SAFETY POLICIES

1. To coordinate and cooperate with other local, state, and federal agencies with expertise and responsibility for all aspects of hazardous wastes.

2. To educate the public on the subject of hazardous wastes.

3. To aid in the identification and mapping of abandoned waste disposal sites, as necessary, and in the survey of the kinds, amounts, locations, etc. of hazardous wastes.

4. To ensure that disaster planning for the City of Selma includes policies appropriate to problems associated with hazardous wastes.

5. To identify the potential hazards from landfills and/or toxic waste sites as a component of environmental review of projects.

6. To prohibit the discharge of toxic and hazardous wastes into the municipal sewer system.

SUMMARY AND POLICY RECOMMENDATIONS

FOR THE

FIVE COUNTY SEISMIC SAFETY ELEMENT

FOR THE

GENERAL PLANS

OF

FRESNO, KINGS, MADERA, MARIPOSA

AND TULARE COUNTIES

AND THEIR RESPECTIVE INCORPORATED CITIES

JULY, 1974

CONSULTANT

ENVICOM CORPORATION

SHERMAN OAKS, CALIFORNIA

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CREDITS

POLICY ADVISORY COMMITTEE

Hon. Robert E. Harrell, Chairman, Representing Tulare County Association of Governments
Kvon G. Cody, Co-Chairman

Council of Fresno County Governments - Representatives

John Donaldson, Supervisor - Fresno County Board of Supervisors
Paul Wasemiller, Councilman - City of Fresno
Johnnie Larson, Councilman - City of Coalinga

Kings County Regional Planning Agency - Representatives

Kvon G. Cody, Supervisor - Kings County Board of Supervisors
Robert S. Hill, Councilman - City of Hanford
Joseph B. Summers - Special District Representative

Madera County - Representatives

Harold Balmat - Board of Supervisors
Donald Handley - City of Madera
Glen Jessing - Special District Representative

Mariposa County - Representatives

William H. Moffitt - Mariposa County Board of Supervisors
Frank L. Long, Jr. - Mariposa County Board of Supervisors
Peter J. Artero - Special District Representative

Tulare County Association of Governments - Representatives

Robert E. Harrell - Tulare County Board of Supervisors and Chairman of the Tulare County Association of Governments
Norman Griesbach - City of Tulare and Vice Chairman of Tulare County Association of Governments
Frank Lagomarsino - Special District Representative, Board of Governors, Tulare County Association of Governments

TECHNICAL ADVISORY COMMITTEE

King Patrick Leonard, AIP, Project Manager and Chairman of Technical Advisory Committee
Dennis Triplitt, Co-Chairman

Council of Fresno County Governments - Representatives

Peter Oswald, Executive Director
David D. Knight, Planning Director

Kings County Regional Planning Agency - Representatives

Charles Gardner, Executive Secretary
Dennis Triplitt, Assistant Director, Kings County Planning Department

Madera County

Leonard Garoupa, Planning Director, County of Madera
Al Muller, City Planner, City of Madera

Mariposa County

Peter J. Artero, County Engineer
William C. Lincoln, Deputy County Engineer

Tulare County Association of Governments

Robert L. Wall, Executive Secretary
King Patrick Leonard, AIP, Division Head, Areawide Planning

CONSULTANTS

ENVICOM CORPORATION

Joseph G. Johns, President
Donald O. Asquith, PhD, Vice President
Charles A. Swift, Geologist
Pamela Tormey, Secretarial

QUINTON/REDGATE (sub contractor)

Elwood C. Teacher, Planning Director
Carl Scheirmeyer, Planner
Michael S. Metcalfe, Planner
Darold A. Nelson, ASCE, Chief Structural Engineer

REPORT PRODUCTION AND GRAPHICS - Tular

County Planning Department

Graphics

Terrill Ohlwein - Graphics Illustrator
Daniel W. Paulson - Draftsman III
Jose B. Aguilar - Draftsman II
Maxine M. Miller - Draftsman II

Clerical

Esther S. Walker - Administrative Secretary
Janice M. Maxwell - Senior Clerk Typist
Elizabeth A. Meyers - Intermediate Clerk Typi

REPRODUCTION - Central Duplicating, Tulare

County

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The following people gave the Policy Committee, Technical Committee and Consultants assistance in the preparation of this report:

Bruce Blackerby - Geology Department, Calif. State University at Fresno

Phil Brumit - Director of Emergency Services, Tulare County

Bill R. Bruner - District Conservationist, USDA Soil Conservation Service - Tulare County

John Buada - Planner, Fresno County Planning Department

John L. Burnett - Geologist, California Div. of Mines and Geology

Tim Cockrum - Geologist, Fresno County Public Works Department

Peter Diaz - Administrator, California Council on Intergovernmental Relations

Ernest G. Eaton - District Conservationist, USDA Soil Conservation Service, Kings County

George Finney - Planner III, Tulare County Planning Department

Thomas E. Gay, Jr. - Geologist, California Division of Mines and Geology

Ray Gonzales - City Planner, City of Clovis

Richard Gresham - Planner, City of Fresno, Planning Department

Gary Irish - Planning Director, City of Porterville

Erik Kaarlela - City of Coalinga/California State Division of Oil & Gas

Donald L. Lucas - District Conservationist, USDA Soil Conservation Service, Mariposa County

Glen Marcussen - City Manager, City of Coalinga

Glen Matteson - Kings County Planning Dept.

Morris A. Martin, Jr. - District Conservationist, USDA Soil Conservation Service, Fresno County

Kerry McCants - Planner, Fresno County Planning Department

Gloria S. McGregor - Assistant Planning Director, Tulare County Planning Department

James W. McCutchan - Building Engineer, Tulare County

Robert Merrill - Geology Department, Calif. State University at Fresno

William Newkirk - Planning Director, City of Tulare

Louis Ollivier - Civil Defense Coordinator, Kings County

Robert W. Palmer - District Conservationist, USDA Soil Conservation Service, Madera County

Douglas A. Powell, Jr. - Planner II, Tulare County Planning Department

Jack Reagan - Planner, City of Fresno Planning Department

H. Duane Smith - City Engineer - Administrator, City of Kerman

Arvey Swanson - Department of Water Resources State of California

Mike Unser - Associate Planner, City of Porterville

Jeffrey Dennis Webster - Planner, Council of Fresno County Governments

Walter Wong - Engineer, City of Fresno

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CHAPTER I SUMMARY

A. FINDINGS AND RECOMMENDATIONS

The large map, Plate I, found in the pocket at the rear of the report and the following matrix summarize the basic findings and recommendations developed by the Five-County Seismic Safety Policy Committee. Plate I displays the seismic zones which are determined by the influencing factors summarized on the map and discussed in the Technical Report, Part I. A simplified map is enclosed for quick reference (page 3) showing study area boundaries and seismic zones. The matrix is developed along these seismic zones indicating the prominent characteristics, areas covered, generalized problem statements and recommendations for mitigation or prevention of seismic safety hazards. The reader can immediately grasp the general conclusions of this study by locating his area of interest within the matrix, examining what the matrix tells him about the problem and possible solutions, and referencing the zone on the map to see what the influencing factors are. This is not a substitute for the more detailed explanation found in the technical report, but a perspective which allows the reader to consider the important aspects in a comprehensive manner.

The Five-County Seismic Safety Policy Committee has attempted to present an objective, adoptable Seismic Safety Element pointing to the areas where value systems must be weighed before making a decision. Any user of this report may choose to find the risk greater or less than the empirical data indicates. This is a choice that responsible local governments must make in determining which recommendations are to be deleted, accepted, or expanded.

B. ADOPTION AND INTERPRETATION BY LOCAL GOVERNMENTS

Seismicity is a regional problem that can best be addressed by a study similar to this one and then modified by the responsible local governmental agencies for implementation.

Steps for Local Government Adoption of this Plan:

I. *Analyze impact of study in relation to your entity.*

II. *Evaluate matrix.*

III. *Locate yourself by zone (or zones). If you find that your city is located in two zones, you should select the level or risk deemed appropriate by your policy body.*

IV. *Look at the problem statement plus the primary and secondary hazards.*

V. *Accept or modify the policy recommendations since these are public decisions based on technical findings.*

VI. *Add other recommendations you may need to this list.*

VII *Modify recommendations to fit your unique needs.*

VIII. *Prepare Environmental Impact Report or Negative Declaration (Appendix indicates a typical County Environmental Impact Report and a model City Environmental Impact Report). Change as necessary in response to V-VII above. State Guidelines suggest that an environmental impact report be submitted to appropriate agencies.*

IX. *Process plan through the normal routes. Public hearings before citizen review committees and planning commissions are required.*

X. *Adopt by resolution referencing or modifying the Five-County Seismic Safety Element.*

XI. *A copy of this resolution should be sent to your County Planning Department; or COG if you are a member of one.*

Enclosed under Appendix A is a sample resolution for your use. Each governmental entity should send a copy of its resolution and attached modifications to:

1. California State Office of Planning and Research
   1400 Tenth Street
   Sacramento, California 95814

2. The Resources Agency
   California Division of Mines and Geology
   1416 Ninth Street
   Sacramento, California 95814

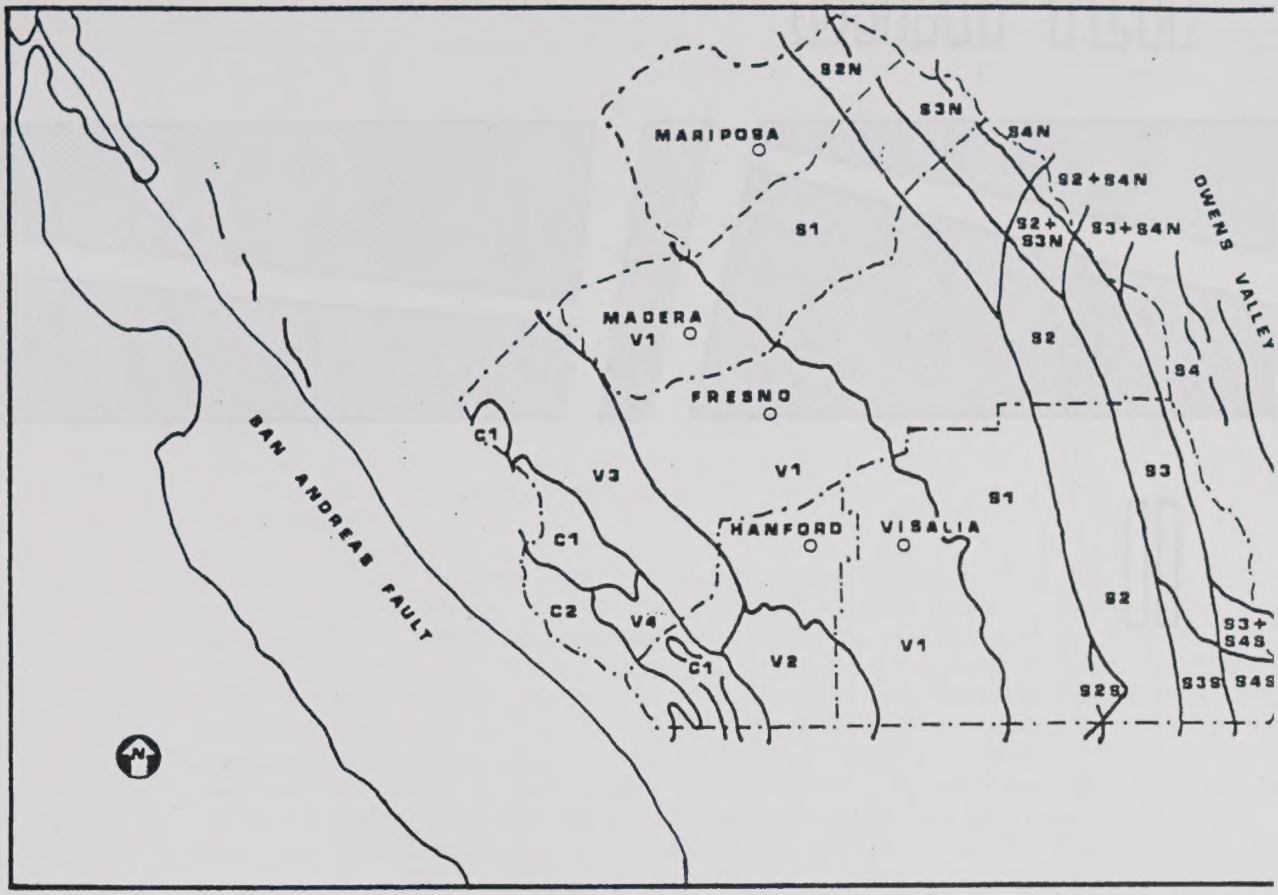
3. The Resources Agency
   State of California
   1416 Ninth Street
   Sacramento, California 95814

4. California State Department of General Services
   Office of Architecture
   1500 Fifth Street
   Sacramento, California 95814

5. Tulare County Association of Governments
   Courthouse, Room 107
   Visalia, California 93277

Copies of the Five-County Study (Contract Number CPA 1032.17) will have been submitted to these agencies and it is not necessary that you submit the entire document; only a resolution and modifications to the report along with the environmental impact report are necessary.

FIVE COUNTY SEISMIC STUDY

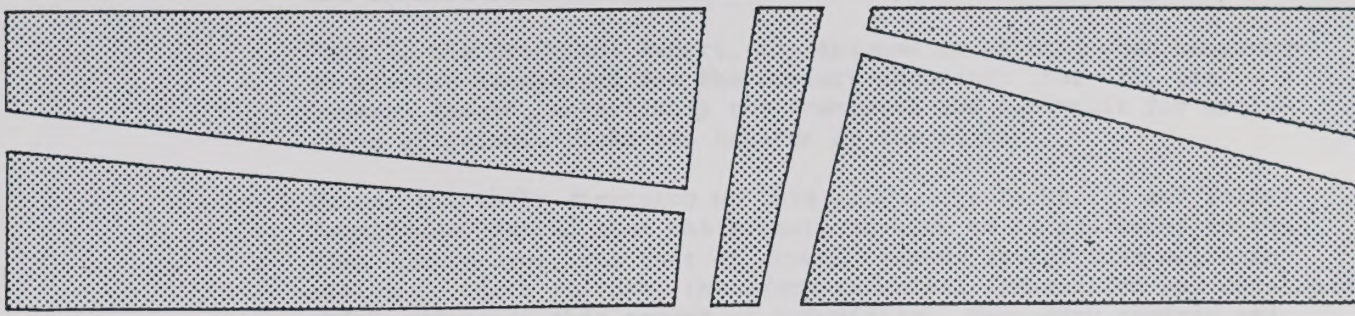


FIVE COUNTY SEISMIC SAFETY ZONES

The above generalized map shows the seismic zones as depicted on "PLATE I" of the Five County Study. Each zone represents how geological and soil conditions, distance, etc. affect the shaking characteristics of an earthquake on major known active faults. It is not appropriate that any one zone be indicated as more hazardous than another since each zone varies in its unique natural and man made characteristics. In general, zones V1, C1, and S1 are "safer" than zones V2, C2, and S2. Secondary hazards resulting from landslides or collapsible soils may be of greater significance in some zones. A more detailed description of the zones is included in the reports.

PREPARED BY TULARE COUNTY PLANNING DEPART

CHAPTER



II

CHAPTER II GENERAL INTRODUCTION

A. APPROACH

Through the provisions made in the contract with CIR, and as a basic philosophy in the conceptual studies preliminary to its development, the Seismic Safety Element has been completed in two stages.

Part I, the Technical Report, is designed to be used when necessary to provide background for the Summary document. Part II, the Summary Report, establishes the framework and rationale for evaluation of seismic risks and hazards in the region.

During the early direction of this study, the Technical and Policy Committees, agreed that the primary problem to be addressed in the Five County area, was that of ground shaking rather than volcanic action or earth rupture; therefore technical information was developed which addressed this aspect of seismicity. Secondary hazards and related geologic problems were also researched and analyzed. Much of this data has been graphically displayed on Plate I of the Technical Report.

Part II of the Seismic Safety Element, the Policy Report, has been prepared as a "model" report designed to address seismic hazards as delineated in the Technical Report. The intent has been to develop a planning tool for use by county and city governments in implementing their seismic safety elements. The hazard conditions discussed in this document may not apply to all jurisdictions and therefore the Summary Report may require some deletions to become specifically representative of a particular jurisdiction. Again; however, the intent has been to provide a document suitable for adoption that will meet the requirements of the State Planning Law (Sec. 65302[f]).

The planning process utilized to develop the Element was developed through the efforts of Technical and Policy Committees, composed of both staff and elected representatives from Cities, Counties, and Special Districts or Areawide Planning Organizations in cooperation with the consulting firms of Envicom Corporation and Quinton-Redgate. Contract management was provided by the Tulare County Association of Governments. The basic philosophy under which this study has been conducted is that the intent of the Seismic Safety Element is to plan and prepare for the future based upon the present state of understanding of seismic hazards, rather than waiting until all desired information is available.

B. PROJECT ORGANIZATION

This study represents a cooperative effort between the governmental entities within Fresno, Kings, Madera, Mariposa and Tulare Counties to develop an adoptable Seismic Safety Element as required by State law. The basic organizational structure is illustrated in Table I.

TABLE I

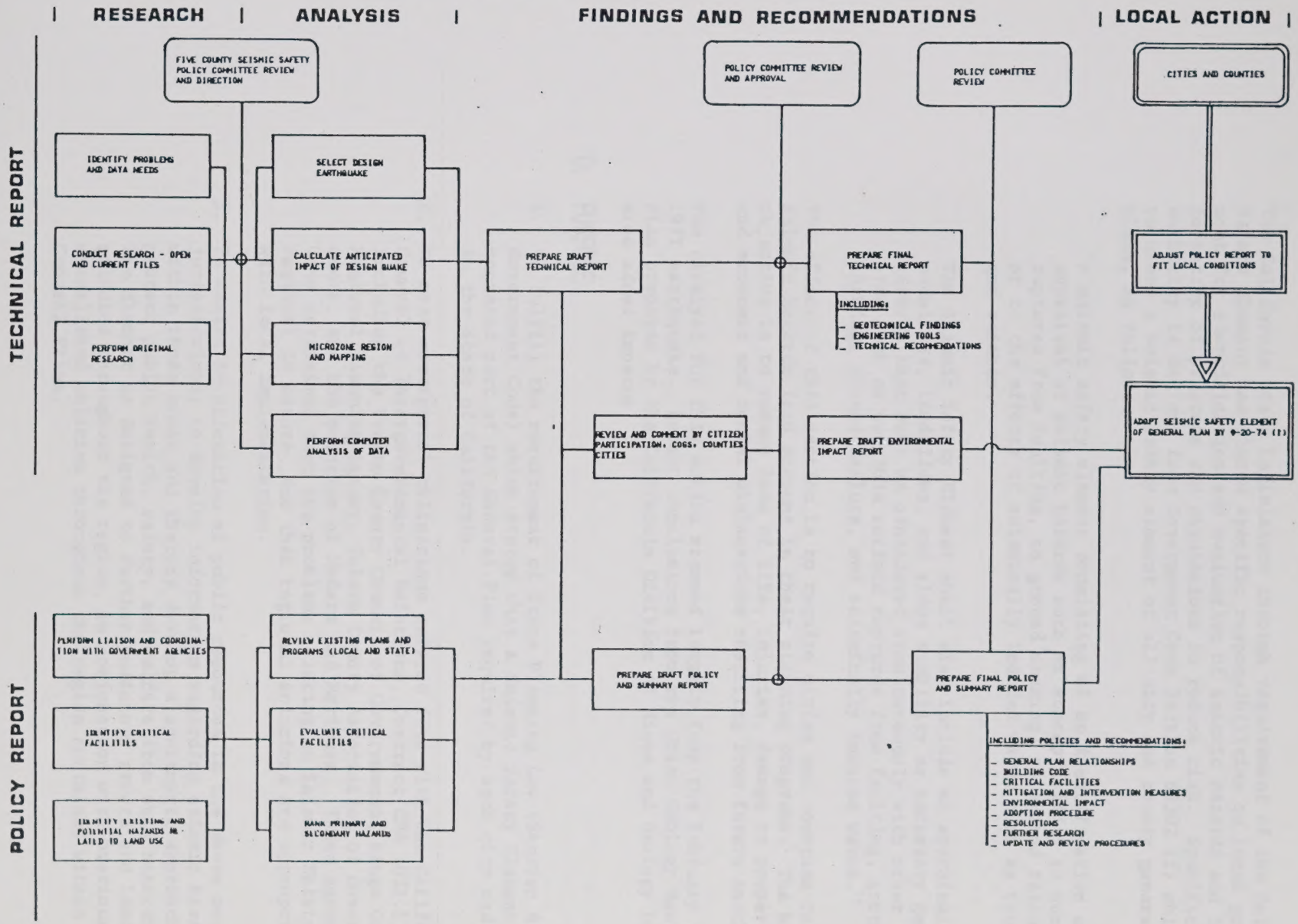
COMPOSITION OF COMMITTEES

	Composition
Five-County Policy Committee	two elected officials for each county and one special district representative
Technical Advisory Committee	two staff persons assigned from each jurisdiction; with assistance from emergency services office staff, engineers, geologists, and related professionals
Consultants	Envicom & Quinton-Redgate
Project Management	Tulare County Association of Governments

The following illustration demonstrates the overall process used to complete the project during the fiscal year 1973-74.

FIVE COUNTY SEISMIC SAFETY STUDY

METHODOLOGY FOR TECHNICAL AND POLICY REPORT PREPARATION



PREPARED BY TULARE COUNTY PLANNING DEPARTMENT

C. REQUIREMENTS OF STATE PLANNING LAW

The California State Legislature through requirement of the Seismic Safety Element has placed specific responsibilities on local government for identification and evaluation of seismic hazards and the formation of programs and regulations to reduce risk. Specific authority is derived from Government Code Section 65302 (f) which requires a seismic safety element of all city and county general plans, as follows:

> "A seismic safety element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves such as tsunamis and seiches.
>
> The Seismic Safety Element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure, and seismically induced waves."

The effect of this section is to require cities and counties to take seismic hazards into account in their planning programs. The basic objective is to reduce loss of life, injuries, damage to property, and economic and social dislocations resulting from future earthquakes.

The catalyst for this action stemmed largely from the February 9, 1971 earthquake. Recent conclusions from the Urban Geology Master Plan prepared by the California Division of Mines and Geology have also added impetus.

D. PURPOSE

1. To fulfill the requirement of State Planning Law (Section 65302[f] Government Code) which states that a Seismic Safety Element is a mandated part of the General Plan required by each city and county in the State of California.

2. To meet contractual obligations entered into with the California Council on Intergovernmental Relations, Contract CPA 1032.17, including the Fresno County Council of Governments, Kings County Regional Planning Agency, Tulare County Association of Governments, and the counties of Madera and Mariposa. These agencies have determined that the problems relating to Seismic Safety are regional in nature, and that regional solutions are appropriate, with local implementation.

3. To assist in allocation of public resources in the above mentioned jurisdictions; to develop information regarding seismic hazards within those areas and thereby develop a systematic approach to protect public health, safety, and welfare from such hazards. The Element is designed to further judicious growth and land use policies throughout the region, in conjunction with previously established policies throughout the region contained within General Plans.

E. GOALS

Goals for Seismic Study are a direct statement of community wide aspirations. These goals are considered to be at least the minimum requirement for a safer environment for the citizens of Tulare, Fresno, Madera, Kings, and Mariposa Counties.

Allocation of resources toward achievement of these goals will be a continuing consideration of decision makers over a long period of time. The achievement of these goals can be met in numerous ways, such as provision of adequate medical facilities, proper disaster planning through the Office of Emergency Services; carrying out of programs that are suggested in this report, and informing the citizenry and government employees of their obligations in time of emergency - of any kind. Should a severe disaster ever occur in the South San Joaquin Valley, it will be up to the citizenry to make many of the decisions necessary for the saving of life and property. Government can help - but it cannot do so without the consent and assistance of its citizens, and it is unreasonalbe to expect that government can do the job alone.

General Goals under which this study was undertaken include:

1. Prevention of serious injury and loss of life

The 1933 Long Beach Earthquake and the 1971 San Fernando Earthquake have taught us many lessons in disaster preparedness, building safety, and hazard prevention. These conclusions are based, in part, on the knowledge gained from those experiences.

Personal injury and loss of life can be reduced in an earthquake. Earthquakes are not the only risk to be considered in a safety program, and the individual counties and cities may elect to spend monies to eliminate or reduce a variety of the "risks" that a community is subjected to. One of the most obvious ways to cut down earthquake "risk" is to design structures to accept a "reasonable" amount of shaking without their coming apart or collapsing. "It is not unreasonable to expect that an increase of 50% greater lateral loading ability can be obtained at an increased building cost of 1%."*

Loss of life and prevention of serious injury is a primary responsibility of local government and should be given highest priority in any seismic safety program.

*The Balanced Risk Concept - New Approach to Earthquake Building Codes. August, 1970 American Society of Civil Engineering Magazine 13.56.

2. Prevention of serious structural damage to critical facilities and structures where large numbers of people are apt to congregate at one time.

The Field Act of 1933 was passed by the State of California in order to eventually eliminate all "unsafe" school buildings. There are still many unsafe school buildings throughout California. The Field Act is scheduled to expire in 1975. Each city and county should assess the structural conditions of schools prior to 1975, and utilize the Field Act while it is still in force.

Hospitals, communication facilities, public facilities, and other critical facilities should be designed to function after an earthquake.

A general structural analysis is required in order to locate structures such as theatres, community centers, and gathering places most likely to be hazardous in an earthquake. Action to be taken in regard to these structures will depend upon the acceptable risk that a community is willing to accept. An "importance factor" should be assigned to all structures in general, prior to cities or counties making a commitment to programs for locating structural hazards.

3. Insuring the continuity of vital services and functions:

This goal is most important in any disaster. It is one of the most important functions of government simply because there is unlikely to be any other organized source of leadership in a major disaster.

Emergency preparedness should include provision of food, water, and shelter in disasters, fire control and prevention, flood control measures, emergency medical care, police protection, utility services, and disease prevention measures. Responsiveness to secondary hazards in an earthquake may be more important than the actual earthquake damage itself. An example is the potential Van Norman Dam disaster after the initial San Fernando Earthquake in 1971. It is estimated that over 80,000 people were living or working below the dam. Had the dam broken, then the disaster would have been far more severe than it was. In order to insure the continuity of vital services, "planning ahead" is essential.

4. Education of the community:

This goal is a necessary ingredient to the success of any planning effort. It is a role to be played by school districts, public agencies, business firms, and other civic minded individuals who have an interest in the safety programs of their communities. Each city and county planning department must assume part of this responsibility along with other public agencies.

F. AVOIDABLE RISK

The CIR Guidelines separate risk into three distinct categories:

(1) ACCEPTABLE RISK - the level of risk below which no specific action by government is deemed to be necessary.

(2) UNACCEPTABLE RISK - the level of risk above which specific action by government is deemed to be necessary to protect life and property.

(3) AVOIDABLE RISK - risk not necessary to take because individual or public goals can be achieved at the same, or less, total "cost" by other means without taking the risk.

Appropriate risk should be determined with maximum citizen input as approriate for each city and county. In making this determination, the appropriate planning response to a potential hazard involves a judgement, either explicit or implicit, of the risk that is acceptable. There is no such thing as a perfectly hazard-free environment. Natural and man-made hazards of some kind and degree are always present. However, efforts can be productively undertaken to try to mitigate the consequences of known hazards.

In the context of the Seismic Element, the problem of risk is one of public policy and the appropriate allocation of public resources to mitigate hazards. The planner's responsibility is to provide a framework in which a communitywide, as opposed to individual, response to the question can be meaningful. The first of several essential steps is the recognition of the presence of a hazard.

Once a problem has been recognized, considerable effort is required to evaluate its likely severity, frequency, and the characteristics of the area involved. This step should take into account the benefit/cost ratio of reducing hazard, acknowledging the intangibles involved, and comparing it with that of other projects. The factors of voluntary and involuntary exposure to risk must be considered in reaching a decision.

Qualification of the above "risk" definitions can be expressed in terms of magnitude and recurrence interval for a specific fault system. In the Five County area, as indicated earlier, the primary concern is with the Owens Valley and San Andreas fault systems. The level of risk associated with events on these faults is indicated by the recurrence interval in much the same manner as the risk from other natural hazards such as flooding. The following table depicts the risk relationships as depicted for normal and critical facilities relative to the San Andreas, Owens Valley and White Wolf fault systems in the Technical Report. It is stressed; however, that this represents only a recommendation of acceptable risk and the public must ultimately decide on the level of risk they deem acceptable.

TABLE II

RISK LEVEL RECOMMENDATIONS

Fault and Segment	Magnitude of Maximum Probable Earthquake (Richter)	Recurrence Interval (years)
San Andreas Fault:		
1857 Break	8.3-8.5	102-155
Transition Zone	8.1-8.3	102-155
Active Area	7.0	100
Owens Valley Fault Group:		
North area	7.0	125
Central area	8.25	300-10,000
South area	6.0	135
White Wolf Fault	7.0	1000-5000

These probable earthquakes are translated in terms of seismic zonation, ground motion, and design criteria in the Technical Report. The results point out an unacceptable risk in several parts of the study area and demonstrate the need primarily for modification to the Uniform Building Code as it now exists for critical facilities in Seismic Zones V3, V4, C1, C2, S2, S3, S4, S3N, S4N, S2S, S3S and S4S (shown on Plate I).

G. CONCLUSIONS

The Policy Report of the Seismic Safety Element is intended to reflect those important conclusions or findings from the technical analysis that may require direct response by government. The range of responses may vary from simple acknowledgement to a substantial revision of a county or city code or ordinance.

Major conclusions from the technical report are as follows:

1. No active faults are known to be present in the Five-County area.

2. The principal earthquake hazard effecting the Five-County area is ground shaking as opposed to surface rupture or ground failure.

3. Known active faults that pose a serious hazard to the Five-County area as being the source of strong ground shaking include the San Andreas fault just west of the area, the Owens Valley fault group to the east, and possibly the White Wolf fault to the south. Analysis of available data on the seismicity, accumulating crustal strain, and rates of geologic slip yield recurrence intervals of the maximum probable earthquakes from these faults as shown in Table II.

   Small local earthquakes may occur from time to time, but their regional effect upon the Five County area is overshadowed in terms of public hazard by the principal faults that significant data has been accumulated on as indicated in Table II.

4. The Five County study area has been divided into sixteen (16) seismic zones, four in the San Joaquin Valley; two in the Coastal Mountains; and ten in the Sierra Nevada Mountains.

5. Comparison of the seismic zonation, developed by mathematical analysis, with the distribution of shaking intensity (isoseismal maps) for the more important historical earthquakes indicates good agreement.

6. Secondary seismic hazards in the Five-County area are considered to be minimal. Significant geological problems do exist however, and should be investigated on a sub-regional basis.

7. The area with the greatest potential for liquefaction is the west side of the San Joaquin Valley however, substantial clay content of the soils may negate the liquefaction hazard.

8. General subsidence due to groundwater withdrawal and differential subsidence due to hydro-compaction are problems in the area of poorly consolidated sediments on the west side of the San Joaquin Valley. This condition includes two areas of "active settlement" shown on Plate I.

9. Slope stability (landslides, mud flows, etc.) has been evaluated in terms of four levels of risk and displayed on Plate I.

10. Tsunamis are not a hazard in the Five-County area and seiches are not considered a significant hazard in the Five-County area.

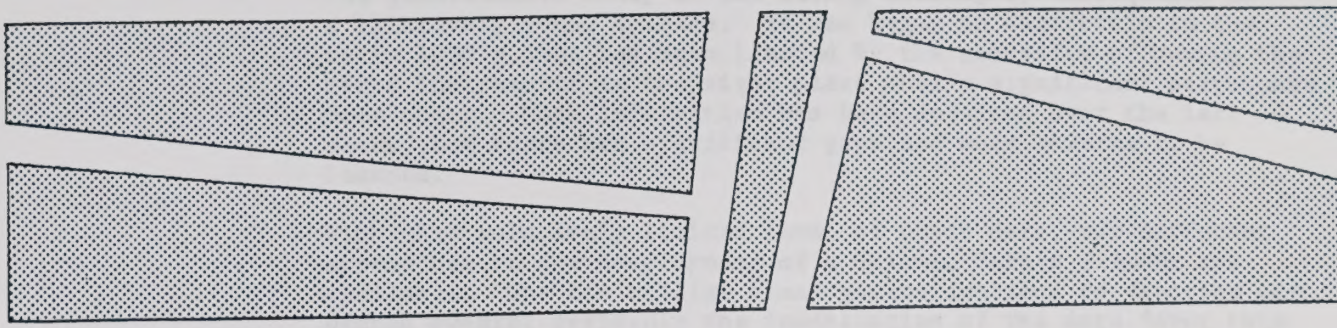
H. STUDY LIMITATIONS

The reviewer and user of this study should understand the various limiting factors associated with it. The Summary and Recommendation Report should be used only as a general policy document. It is supported by a Technical Report, which offers the necessary backup for references of a technical nature. Also, this study was developed at a five-county scale as an advisory reference document to local general purpose government (counties and cities). Only these local governments have the power to enact and implement the proposed plan in whole or part. All policy and implementation recommendations are advisory and specific local government units should be contacted as to their enactments regarding these issues. The Element becomes policy only upon adoption in whole or in part by general purpose local governments in the study area.

A special warning is necessary for those utilizing these documents as support or reference for environmental impact statements. This was developed at a macro, five-county scale without indepth attention to specific locations. Consequently, it can be used as a guide or warning of environmental problems relating to specific locations. It does not substitute for an on-site investigation for specific project proposals. It may indicate whether on-site investigations are feasible.

Finally, the project scale may overlook certain unique characteristics or features relating to a particular geographic area or city. These unique features can only be treated by those entities responsible for them. For example, no structural analysis was undertaken of the numerous tall structures in the study area. This study only generally treats this topic. Particular cities may choose to conduct more indepth analysis of the older or tall structures in their area.

CHAPTER



III

CHAPTER III METHODOLOGY

A. PHILOSOPHY OF THE ANALYSIS

The quantitative study of the strong shaking by earthquakes is a relatively young science. It was begun in California in the early 1930's, but has been limited by the necessity of having the right instruments in the right place when a significant earthquake does occur. Much information has been acquired over the last 40 years, but there are significant gaps and much remains to be learned.

With this relatively limited level of basic data, two different approaches to the development of a Seismic Safety Element are available. One can utilize broad generalizations to describe expected events; certainly the inadequacies of the data favor this approach. On the other hand, if the results are to be used by engineers in designing safer structures, then a commitment to mathematical form is necessary. To this end, the analysis is developed mathematically, whenever possible, and presented in chart or graph form. Qualitative descriptions of the results are included for the lay reader.

The basic philosophy within which this analysis has been developed is that the intent of the Seismic Safety Element is to plan and prepare for the future based on what we know today rather than waiting until we know all that we would like to know.

B. TYPES OF HAZARDS

The several seismic hazards discussed in the C.I.R. Guidelines can be grouped as a cause-and-effect classification that is the basis for the order of their consideration. Earthquakes originate as the shock wave generated by movement along an active fault. The *primary natural hazards* are ground shaking and the potential for ground rupture along the surface trace of the fault. *Secondary natural hazards* result from the interaction of ground shaking with existing ground instabilities, and include liquefaction, settlement, and landslides and seiches (waves in lakes or reservoirs). In this context, tsunamis, or "tidal waves," and seiches (often considered secondary hazards) would be primary natural hazards.

The potentially damaging natural events (hazards) discussed above may interact with man-made structures. If the structure is unable to accommodate the natural event, failure will occur. The potential for such failure is termed a *structural hazard*, and includes not only the structures themselves, but also the potential for damage or injury that could occur as the result of movement of loose or inadequately restrained objects within, on, or adjacent to a structure.

The products developed in the seismic study, as documented in the Technical Report, are primarily displayed on Plate I. They include seismic zones and secondary hazard areas.

C. ZONATION AND SEISMIC ZONES

The derivation of the sixteen seismic zones has been documented in the Technical Report. They are expressive of the level of ground motion that can reasonably be anticipated from earthquakes on the principal fault systems affecting the Five County area. The characteristics of each seismic zone are represented by response spectra which translate ground motion into displacement (inches); velocity (inches per second); and acceleration (inches per second per second expressed as a percent of the acceleration of gravity). These three factors which are derived from mathematical analysis are essentially the descriptors of each seismic zone. These are engineering "tools" for use in designing structures.

The microzonation of the Five-County area for the effects of ground shaking originating from earthquakes on the San Andreas fault to the west or the Owens Valley fault system to the east is based on a computer-assisted method of analysis discussed in the technical section of the report. The methodology has been developed through the study of earthquakes on a world-wide basis, and has been applied and tested most recently in the study of the San Fernando and Managua earthquakes through the School of Engineering at the University of California at Los Angeles.

The method analyzes the variation in earthquake shaking resulting from variation in earth properties. Variations in the San Joaquin Valley and the Coastal Mountains were evaluated at fourteen locations chosen for their proximity to population centers, availability of data, and to test critical variations in earth properties. Variations in the Sierra Nevada Mountains are based on tests of similar conditions from other studies.

The zonation resulting from the mathematical analysis is compared to variations in intensities of shaking observed in and near the Five-County area during past earthquakes. The results of this comparison indicate that the analysis is consistent with past experience.

ZONES

The engineering characteristics of ground shaking expected in the several zones are described in the technical section. Generalized characteristics are listed below:

Zone V1 includes most of the eastern San Joaquin Valley, and is characterized by a relatively thin section of sedimentary rock overlying a granitic basement. Amplification of shaking that would affect low to medium-rise structures is relatively high, but the distance to either of the faults that are the expected sources of the shaking is sufficiently great that the effects should be minimal. The requirements of Zone II of the Uniform Building Code should be adequate for normal facilities.

Zone V2 includes the south-central portion of the San Joaquin Valley that is within the Five-County area, and is characterized by a relatively thick section of sedimentary rock overlying a granitic basement. Amplification of shaking that would affect low to medium-rise structures is low, and the distance to the San Andreas fault is moderate. The combined effect is that shaking is expected to be minimal, and the requirements of Zone II of the Uniform Building Code should be adequate for normal facilities.

Zone V3 includes the western side of the San Joaquin Valley north of the Kettleman Hills, and is characterized by a thick section of sedimentary rock. Amplification of shaking is reduced by the damping effect of the thick sedimentary section, but moderate proximity to the San Andreas fault results in a moderate increase in expected shaking over that for the east side of the valley. The requirements of Zone III of the Uniform Building Code should be adequate for normal facilities.

Zone V4 includes the Coalinga area and the larger valleys to the south and west, and is characterized by a thick section of sedimentary rock. Amplification of shaking is reduced by the damping effect of the thick sedimentary section, but relatively close proximity to the San Andreas fault results in the expectation of moderately high shaking characteristics. The requirements of Zone III of the Uniform Building Code should be adequate for normal facilities.

Zone C1 includes the eastern portion of the Coastal Mountains and the Kettleman Hills, and is characterized by a thick section of firm to hard sedimentary rocks. Amplification of shaking is low because of the firm to hard rock, but the area is relatively close to the San Andreas fault. This combination results in moderate to moderately high shaking characteristics. The requirements of Zone III of the Uniform Building Code should be adequate for normal facilities.

Zone C2 includes the mountainous areas closest to the San Andreas fault, and is characterized by a moderately thick section of firm to hard sedimentary rock with some metamorphic rock locally. Amplification is low, but the proximity to the fault should result in moderately high to high shaking characteristics. The requirements of Zone III of the Uniform Building Code should be adequate for normal facilities.

Zone S1 the eastern, roughly one-half of the Sierra Nevada Mountains, and is characterized by hard to moderately hard granite or metamorphic rock. The distance to either of the faults expected to be a source of shaking is sufficiently great that shaking should be minimal and the requirements of the Uniform Building Code Zone II should be adequate for normal facilities.

Zone S2 is located in the central Sierra Nevada Mountains and is closer to the Owens Valley fault than Zone S1. Shaking should be minimal to moderate on hard rock, but would be more intense on the alluvium of the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S3 is located in the eastern Sierra Nevada Mountains, and is closer to the Owens Valley fault group than either Zones S1 or S2. Shaking should be moderate on hard rock, but could be intense on the alluvium of the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S4 is located in the extreme eastern Sierra Nevada Mountains, and is the closest zone to the Owens Valley fault group. Shaking should be moderate to strong on hard rock, but could be very intense on the alluvium in the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S2N is located in the northeastern part of the study area, and is characterized by hard to moderately hard granite or metamorphic rock. It is within the zone of influence of the seismically active area north of the Owens Valley fault. Shaking should be minimal to moderate on hard rock, but would be more intense on the alluvium of the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone II should be adequate for normal facilities.

Zone S3N is located in the northeastern part of the study area, and is characterized by hard to moderately hard granite or metamorphic rock. It is within the zone of influence of the seismically active area north of the Owens Valley fault. Shaking should be moderate on hard rock, but could be intense on the alluvium of the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S4N is located in the extreme northeastern part of the study area, and is characterized by hard to moderately hard granite or metamorphic rock. It is within the zone of influence of the seismically active area north of the Owens Valley fault. Shaking should be moderate to strong on hard rock, but could be very intense on the alluvium in the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S2S is located in the southeastern part of the study area, and is characterized by hard to moderately hard granite or metamorphic rock. It is within the zone of influence of the seismically active area south of the Owens Valley fault. Shaking should be minimal to moderate on hard rock, but would be more intense on the alluvium of the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S3S is located in the southeastern part of the study area, and is characterized by hard to moderately hard granite or metamorphic rock. It is within the zone of influence of the seismically active area south of the Owens Valley fault. Shaking should be moderate on hard rock, but could be intense on the alluvium of the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S4S is located in the extreme southeastern part of the study area and is characterized by hard to moderately hard granite or metamorphic rock. It is within the zone of influence of the seismically active area south of the Owens Valley fault. Shaking should be moderate to strong on hard rock, but could be very intense on the alluvium in the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

Zone S4S is located in the extreme southeastern part of the study area, and is characterized by hard to moderately hard granite or metamorphic rock. It is within the zone of influence of the seismically active area south of the Owens Valley fault. Shaking should be moderate to strong on hard rock, but could be very intense on the alluvium in the valleys or on thick sections of weathered bedrock in the mountain meadows. The requirements of the Uniform Building Code Zone III should be adequate for normal facilities.

In discussing the three major groupings of the seismic zones the following general statements can be made:

1. The Sierra Zones (S1, S2, S2N, etc.) have the lowest near-surface amplification except locally in the alluvial valleys. The degree of amplification in the alluvial valleys is highly variable and dependent upon such factors as alluvium thickness and ground motion.

2. The Coastal Mountain Zones (C1, C2) also have low near-surface amplification but these zones are so close to the San Andreas fault that the ground shaking levels will be moderately high.

3. The Valley Zones (V1, V2, etc.) vary with respect to near-surface amplification across the study area roughly in an east-west vertical pattern (see Plate I). The highest near-surface amplification occurs in the west valley and decreases to the east due to damping of the thick alluvial section.

As ground shaking is the principal seismic hazard in the Five-County area, the seismic zones, described in terms of response spectra, become the major planning tool to relate ground shaking to land use. In discussing ground shaking and land use; however, the prime concern is for the safety of residential dwellings, work centers, and emergency and health care facilities. The key to establishing a firm relationship between these areas is the Uniform Building Code which governs construction of man's shelters. For purposes of this study these shelters have been divided into normal facilities and critical facilities. A discussion of the definition and types of critical facilities is detailed later in this Summary Report.

The two following tables for normal and critical facilities depict the relationships between the seismic zones and the recommended seismic design forces for the standard zones of the 1973 Uniform Building Code. These tables have been prepared utilizing commonly applied structural engineering evaluation techniques.

TABLE III

UNIFORM BUILDING CODE SEISMIC ZONE AND DESIGN FORCE MULTIPLICATION FACTOR

FOR

NORMAL FACILITIES

Seismic Zone	Earthquakes (Magnitude)	Source Fault	Recurrence (years)	UBC (Zone)
V 1	8.0-8.5	San Andreas	100-150	II
V 2	8.0-8.5	San Andreas	100-150	II
V 3	8.0-8.5	San Andreas	100-150	III
V 4	8.0-8.5	San Andreas	100-150	III
C 1	8.0-8.5	San Andreas	100-150	III
C 2	8.0-8.5	San Andreas	100-150	III
S 1	7.0	Owens Valley	125	II
S 2	7.0	Owens Valley	125	III
S 3	7.0	Owens Valley	125	III
S 4	7.0	Owens Valley	125	III
S 2 N	7.0	Owens Valley	125	II
S 3 N	7.0	Owens Valley	125	III
S 4 N	7.0	Owens Valley	125	III
S 2 S	6.0	Owens Valley	135	III
S 3 S	6.0	Owens Valley	135	III
S 4 S	6.0	Owens Valley	135	III

For purposes of this Summary Report, normal facilities include all facilities not specifically defined as critical. An in depth discussion of critical facilities is presented in the next section. It should be stressed; however, that each local government may, at its discretion, designate other facilities not specifically listed (Appendix D) as critical or may delete facilities from the critical facilities listings. In this case, those deleted facilities would become normal facilities.

TABLE IV

UNIFORM BUILDING CODE SEISMIC ZONE AND DESIGN FORCE MULTIPLICATION FACTOR FOR CRITICAL FACILITIES

Seismic Zone	Earthquakes (Magnitude)	Source Fault	Recurrence (years)	UBC (Zone)
V 1	8.0-8.5	San Andreas	100-150	II x 2
V 2	8.0-8.5	San Andreas	100-150	II x 2
V 3	8.0-8.5	San Andreas	100-150	III x 1.5
V 4	8.0-8.5	San Andreas	100-150	III x 2
C 1	8.0-8.5	San Andreas	100-150	III x 1.5
C 2	8.0-8.5	San Andreas	100-150	III x 2
S 1	8.25	Owens Valley	300-10,000	II x 2
S 2	8.25	Owens Valley	300-10,000	III x 1.5
S 3	8.25	Owens Valley*	300-10,000	III x 1.5
S 4	8.25	Owens Valley	300-10,000	III x 2
S 2 N	7.0	Owens Valley	125	II x 2
S 3 N	7.0	Owens Valley	125	III x 1.5
S 4 N	7.0	Owens Valley	125	III x 1.5
S 2 S	6.0	Owens Valley	135	III x 1.5
S 3 S	6.0	Owens Valley	135	III x 1.5
S 4 S	6.0	Owens Valley	135	III x 1.5

The UBC multiplication factors for critical facilities as shown above, refer to an increase in seismic design requirements over and above those required for standard UBC Zones. For example, (II x 2) indicates that new construction in a particular seismic zone, say V1, (Plate I) is to be doubled over those building design requirements normally required for UBC Zone II.

*Configuration of the S-3 Zone in extreme southern Tulare County is modified slightly for expected earthquakes from the White Wolf fault.

D. SECONDARY HAZARDS

The evaluation of earthquake-related geologic hazards, such as landslides, seiches, settlement, liquefaction, etc., has been based on research and analysis of available maps and reports and on the study of aerial photographs of the area. Emphasis in this part of the investigation was placed on areas of expanding urbanization, such as slopes adjacent to lakes and reservoirs, and major mountain roads. The results are shown on Plate I of the Technical Report, and the detailed explanation of methods and results is given in the Technical Report (Phase I).

Phase I has been structured to enable easy secondary hazard problem identification to be handled by each county on an individual basis. Because secondary hazards vary from county to county, some individual refinement may be necessary prior to each county's adoption of its particular seismic safety element.

CHAPTER

IV

CHAPTER IV POLICIES AND IMPLEMENTATION RECOMMENDATIONS

The State of California considers the threat of earthquake serious enough to require a Seismic Safety Element in the General Plan of all incorporated governmental bodies. At the same time, it should be realized that the threat of earthquake is not the same at all times or in all places. This Seismic Safety Element traces the impacts of a maximum probable earthquake from the San Andreas, Owens Valley, and White Wolf fault systems on the Five County area. The preceding discussion of critical facilities and structural analysis has indicated that local governments can initiate many actions to counter these anticipated impacts. The following represents a summation of the important study findings and is presented as Policy Recommendations for review and eventual adoption by each counties' Board of Supervisors.

A. POLICY RECOMMENDATIONS

1. Adoption of Seismic Safety Element by each city and county (Government Code 65302[f].)

2. Integrate the Seismic Safety Element with other general plan elements.

3. Develop a Safety Element to the General Plan (Government Code 65302.1)

4. Develop an Earthquake Disaster Plan.

5. Establish an Emergency Services Program for each county. Objectives of the program should be part of the "Management Philosophy" of each county. Included in such a program should be:

   - To coordinate a structural hazards inspection program and establish for each counties' Board of Supervisors the necessary criteria for mitigation of hazards.

   - To provide a basis for control and direction of emergency operations.

   - To release a disaster information in concurrence with county Boards of Supervisors during or immediately after a disaster.

   - To provide for the continuity of government in the event of a geologic disaster.

   - To coordinate, repair, and restore essential systems and services as required in an emergency.

   - To provide for the protection, use and distribution of remaining resources as well as surplus property available from the Federal Government for local government use.

- To coordinate operations with the Civil Defense Emergency Operations of other jurisdictions as necessary.

6. Community programs that train volunteers to assist police, fire, and civil defense personnel how to perform effectively after an earthquake, should be supported.

7. Emergency communication centers, fire stations, and other emergency service facilities should be examined as to their earthquake resistant capacities. If found below acceptable standards, a program to mitigate potential hazards should be immediately established.

8. Emergency procedures should be identified for public and private utility districts.

9. Establish evacuation routes in cities and counties.

10. Review dam safety in light of study findings.

11. Review water transfer facilities in light of study findings.

12. Review utility transfer facilities in light of study findings.

13. Review commodity transfer facilities in light of study findings.

14. Establish a public relations and education program to create community awareness.

15. Establish a seismic safety review and monitoring program.

16. Consideration of seismic and secondary hazard aspects in the environmental impact assessment process.

17. Seismic aspects must be addressed in the environmental reporting process.

18. Section 65402 (Planning Law) and Section 11525 (Subdivision Map Act) of the Government Code require that developments be submitted for governmental review. The local governments should enforce these provisions taking into account recommendations from the Seismic Safety Element Report.

19. Establish public investment and capital improvement safeguards for hazardous areas.

20. Property reports should be furnished to prospective buyers of property.

21. Open Space zoning in hazardous areas.

22. Recommendation for site investigations:

    a. landslides
    b. subsidence/settlement
    c. flooding
    d. local soils/geologic conditions

23. Chapter 70 of the Uniform Building Code 1973 edition, should be adopted and enforced. To insure this, entities involved should retain on a full or part-time basis, a qualified engineering geologist to review reports and perform other functions related to implementation.

24. A Building Code enforcement program should be initiated.

25. Consideration should be given to the possibility of developing a "dangerous building ordinance."

26. The local governments, assisted by the County Building and Safety Departments, should initiate a vigorous inspection program of all unreinforced masonry structures.

27. A review committee should be established by the Board of Supervisors to consider the desirability of initiating condemnation proceedings against unreinforced masonry structures found to be unsafe.

28. Structures of more than four (4) stories should utilize a dynamic analysis procedure for assessing structural design requirements.

29. A building strong-motion instrumentation program should be instituted for buildings over six (6) stories in height with an aggregate floor area of 60,000 square feet or more, and every building over ten (10) stories in height regardless of floor area.

30. All critical facilities constructed prior to 1948 should be reviewed by a structural engineer for potential hazards. Since many of these structures have regional impact, the source of funding for the inspection program ought to be at the regional level.

31. Adopt the Uniform Building Code, 1973 Edition, with the following modifications: Seismic Zones V1, V2, S1, and S2N utilize Zone II of the UBC; Seismic Zones V3, V4, C1, C2, S2, S3, S4, S3N, S4N, S2S, S3S, and S4S remain in the UBC Zone III.

32. Critical facilities are to be designed at double the seismic design forces in Zones V1, V2, V4, C2, S1, S4, and S2N; and at 1-1/2 the seismic design forces in Zones V3, C1, S2, S3, S3N, S4N, S2S, S3S, and S4S. (Table IV)

33. For critical facilities, the bracing and anchorage of all mechanical and electrical equipment should be designed for lateral seismic forces equal to 20% of its total dead load in seismic zones V1, V2, S1, and S3N; and 40% in zones V3, V4, C1, C2, S2, S3, S4, S3N, S4N, S2S, S3S, and S4S.

34. The Technical Report should be made available to developers for review.

35. Current County Disaster Plans should be revised to reflect programs to mitigate the potential loss of water on the west side of the Central Valley in the event of damage to the California Aqueduct in a geologic disaster.

36. New construction directly astride or across known faults, or fault zones, should be prohibited. Non-structural land uses, however, should not be prohibited.

37. Each county should develop an information release program to familiarize the citizens of the region with the Seismic Safety Element. School districts and agencies related to aged, handicapped and seismically susceptible industries should be encouraged to develop education programs relative to seismic awareness.

38. Upon adoption of this element, each county should establish a Seismic Safety Review Committee to oversee the implementation of this element. This committee should be composed of the Director of Building and Safety, the Director of Public Works, the Planning Director, and the Director of the Office of Emergency Services and at least one representative from police and fire protection service agencies.

39. The Seismic Safety Element should be reviewed by each county planning department annually and should be comprehensively revised every five years or whenever substantially new scientific evidence becomes available.

B. IMPLEMENTATION AND RECOMMENDATIONS

EDUCATION

- Present seismic study findings using slide presentations and workshop meetings to schools, agencies related to aged, handicapped, etc., and seismically susceptible industries.

- Establish appropriate media for reaching different segments of county communities (Spanish-speaking) and conduct presentations.

- Present findings to appropriate civic groups.

- Make available to builders and developers findings of the Seismic Safety Element.

- Encourage State, Federal and other governmental agencies to intensify research on seismic and other geologic hazards.

CONSERVATION (General Plan)

- Relate findings of Seismic Safety Element to Open Space, Land Use, Circulation, Safety, Housing, and Scenic Highways Elements.

- Review and update grading ordinances.

- Update zoning ordinance and make desired changes.

- Review subdivision requirements and make recommendations to the Boards of Supervisors and planning commissions on implications of the Seismic Safety Element and make desired changes.

- The California Department of Water Resources should review the Seismic Safety Element and forward comments regarding dams and the aqueducts to each county's Public Services Director.

- CALTRANS should review the Seismic Safety Element with respect to Interstate 5 and other major highways and forward comments to the affected counties. Individual county circulation elements should then be revised, if necessary.

- Establish procedures for dealing with geologic reports and investigations particularly when critical facilities are involved.

EMERGENCY SERVICES PROGRAM

- Implement emergency service requirements of Seismic Element in a declared disaster and coordinate activities of police, fire, civil defense and volunteer activities.

- Prepare geologic disaster information release programs for use in emergencies.

CHAPTER

V

CHAPTER V CRITICAL FACILITIES

A. DEFINITIONS

The Technical Report describes in great detail the characteristic response spectra of all hypothetical maximum probable earthquakes affecting the Five-County area of Kings, Tulare, Fresno, Madera and Mariposa Counties. From this information different seismic zones have been specified.

The seismic zones of themselves do not have an immediate relationship to public policy. To assist local governments in the development of public policy the seismic zones must be related to the possible effects of an earthquake on major structures and the occupants of these structures. The concept of "Critical Facilities" developed in this report provides the necessary information that will allow for the development of public policy.

A structure is considered critical when one or both of the following criteria are met:

1. The failure of the structure would present a high degree of danger to a large number of people.

2. The failure of the structure would severely impair the ability of the community to respond in an emergency.

B. TYPES OF CRITICAL FACILITIES

The use of the first criterion involves of necessity considerable subjectivity. At what point is there a "high degree of danger" and what is a "large number of people?" Without a doubt the loss of even a single life in an earthquake or the destruction of a single structure in the most remote section of the study area is significant. Yet at the level of public policy it is difficult if not impossible to formulate plans to cover all such contingencies.

Historically the public has been particularly concerned about certain types of structures more than others. These structures - schools, hospitals and dams - are regulated more closely and in this report are considered "critical" in every case.

The second type of critical facility is more easily definable. Hospitals would fall into this category as well as the previous one. Fire stations, police stations, bridges, radio stations are some examples of facilities required by communities to insure rapid and competent response to major disasters. In Appendix D there is an index and listing of critical facilities for each county in the study area.

Because of the regional emphasis of the Five County Study, the list of critical facilities for each County is presented either in relation to the community in which the facility occurs or in relation to other identifying features. Except for dams, the exact location of each facility is not recorded. The list of critical facilities for each county is included in the appendix.

Some facilities, notably aqueducts and major highways, are indicated whenever they fall within a community. But these types of facilities extend beyond communities as well and thus should be considered critical wherever they are located.

C. STRUCTURAL HAZARDS

The structural analysis was conducted by a structural engineer licensed in the State of California. Based on the response spectra for each seismic zone, the analysis has reviewed the building code requirements as specified in 1973 as well as previous building code provisions. Additionally the analysis has attempted to develop generic statements about structural quality. In no cases have any buildings been inspected for this report. This structural analysis has also focused only on the ability of a structure to protect the occupants of that structure. Historically, the purpose of the earthquake provisions of the building code have been to prevent loss of life, not to prevent damage to the structure. In no case should any conclusions reached in this analysis be extended to include the potential range of damage to structures themselves.

The analysis examined existing structures and modifications to the building code for future structures.

1. Existing Structures

a. Normal Structures

Assuming that earthquake provisions of the Uniform Building Code were followed by builders and that the local governments maintained appropriate enforcement procedures, buildings constructed within the past twenty-five years or so should be considered safe. Prior to approximately 1948, wood frame structures two stories or less should also be considered safe. Other buildings constructed before 1948 should be considered suspect. In all cases, unreinforced masonry buildings should be considered hazardous. In the absence of detailed structural evaluations, all masonry buildings constructed prior to 1933 should be considered dangerous.

b. Critical Structures

For existing pre-1948 structures that have been labeled as "critical facilities," such as schools and hospitals, there should be a detailed structural investigation to determine the integrity of the building. For all structures, special attention should be given to such questions as the anchorage of the structure to the foundation, the anchorage of the chimney to the structure, the anchorage of exterior ornamentation, parapets and roofing tiles to the structure and the amount of discontinuity in the structural composition of each building. During the recent Managua earthquake it was found that the collapse of hanging ceilings presented additional hazards to occupants.

2. Future Structures

a. Normal Structures

Comparison of the response spectra in the Technical Report with the Earthquake provisions of the Uniform Building Code, 1973 edition indicates that the Uniform Building Code, 1973 edition, is appropriate for the circumstances expected in the Five-County area with the following modifications. Seismic design forces for Zone II would be appropriate for structures in Zones V1, V2, S1, and S2N. Seismic design forces for Zone III would be appropriate for the remainder of the study area, as noted below.

Seismic Zone	Uniform Building Code, 1973 Edition Zone II	Zone III
V1, V2, S1, S2N	X	
V3, V4, C1, C2, S2, S3, S4, S3N, S4N, S2S, S3S, S4S		X

Currently the entire State of California is classified in Zone III.

b. Critical Structures

Regarding critical facilities, additional requirements are recommended. For Zones V1, V2, V4, C2, S1, S4, and S2N, the seismic design forces should be doubled. The seismic design forces should be increased by one and one-half in Zones V3, C1, S2, S3, S3N, S4N, S2S, S3S, and S4S. The following chart summarizes these recommendatior

Seismic Zone	Zone II 1.5 x code	Zone II 2 x code	Zone III 1.5 x code	Zone III 2 x code
C1			X	
C2				X
V1		X		
V2		X		
V3			X	
V4				X
S1		X		
S2			X	
S3			X	
S4				X
S2N		X		
S3N			X	
S4N			X	
S2S			X	
S3S			X	
S4S			X	

c. Large Private Structures

Builders of proposed high-cost, high-occupancy private structures should be encouraged to review this report and modify the seismic design forces where indicated. Additionally, for critical facilities it is recommended that an on-site seismic-geologic study be conducted. Proposed critical facilities of more than four stories should be designed utilizing dynamic analysis procedures.

d. Additional Engineering Precautions

The preceding structural review took into account known information relative to damping and the natural periods of buildings. For critical facilities, additional precautions should be taken for support equipment contained within the buildings. The bracing and anchorage of all critical mechanical and electrical equipment (including piping, light fixtures, etc) should be analyzed and designed for seismic forces. The following publications contain comprehensive criteria for this use. "Mechanical and Electrical Equipment Supports," Kaiser Steel and Section 8 of "Seismic Design of Buildings," TM 5-809-10; NAV FAC P-355; Air Force Manual No. 88-3, Chapter 13 (available to most government agencies). In lieu of the above referenced criteria, it is suggested that mechanical and electrical equipment be designed for lateral seismic forces equal to 20% of its total dead load in microzones V1, V2, S2N, C1 and S1; and 40% of its total dead load in microzones V3, V4, C2, S2, S3, S4, S3N, S4N, S2S, S3S, and S4S.

D. COST IMPLICATIONS OF SEISMIC DESIGN

Based on structural engineering experience, implementation of the additional seismic design forces recommended in this section could add approximately 1-10% to the cost of the structure depending upon the type of structure and occupancy requirements.

TABLE V

TAXONOMY OF CRITICAL FACILITIES

Facility	Potential Effect on Loss of Life	Required for Community Functioning
Dams	X	
Electrical Sub-Stations		X
Schools/Colleges	X	
Fire Stations		X
Railroad Lines		X
Aqueducts	X	
County Buildings	X	
City Buildings	X	
Hospitals	X	X
Sewage Treatment Plants		X
Water Works		X
Radio Stations		X
Television Stations		X
Microwave Stations		X
Highway Patrol Offices		X
Major Highways/Bridges	X	X
Highway Tunnels	X	X

CHAPTER

VI

CHAPTER VI SEISMIC SAFETY

A. REDUCING SEISMIC HAZARDS

1. Philosophy

Two basic concepts should be considered in the upgrading and enforcing of building codes involving seismic risk. First, the basic concern of the County is the safety of its citizens. To implement this concern, it should adopt and enforce a code for the design and construction of new structures that will protect them, at an acceptable level of risk, against death or serious injury. That is, a structure may be rendered completely useless due to damage during an earthquake; but if it does not collapse and no one is killed or seriously injured, then the structure has performed adequately from the standpoint of public safety. The owner of the structure may choose to upgrade the design to provide additional protection against damage.

The second basic concept is that certain critical facilities such as hospitals, fire and police stations, and communications centers will be required to function at peak efficiency in the hours immediately following a damaging earthquake. The level of protection desirable for a home or an office building may not be adequate for the structures in which these necessary services are housed.

2. Steps To Be Taken To Reduce Seismic Hazards

Working under the seismic parameters as presented in the Technical Report, a systematic inspection and structural analysis of existing structures in each County should be undertaken. Such a program should be under the direction of each counties' Department of Building and Safety. The most important existing structures are, of course, critical facilities and those designated as public buildings. It is with these buildings that the structural evaluation processes should begin.

For existing structures that are non-critical in nature the following table (abridged from Pacific Fire Rating Bureau) shows relative damageability of varying structural types. This table can be used as a general indicator in older construction to establish a priority ranking for evaluation of non-critical structures. As an example, buildings with a high susceptibility to damage rating (five or over) should be selected for structural inspection before those with low ratings.

Critical facilities or public structures shown to be of inadequate construction should be noted and schedules for demolition or reinforcement on a priority basis. If it is not economically feasible to provide an adequate level of protection by strengthening a structure, a lower level of occupancy may be desirable. If many high-risk structures are located in one area, redevelopment may be a solution.

Owners of existing commercial and residential buildings with obvious structural weaknesses should be notified of the conditions so appropriate repairs can be affected. In cases where the private owner is reluctant to take appropriate action, or where the costs of repairs are prohibitive, the local cities should at least take measures to protect the general public.

A program of this type is not without many social and economic problems and may require several years to complete. A reasonable time interval for completion of such a structural analysis program of existing buildings would be five years. As discussed earlier, earliest attention should be given to critical facilities. Their ability to function immediately after an earthquake will affect all the citizens of the county and each city, and they should receive the highest priority.

In considering future construction relative to areas of potential liquefaction, prime emphasis should be placed upon communicating to developers and builders the findings of this report. The problem of potential liquefaction (Plate I) should be handled on a site-by-site basis by a licensed Soils Engineer.

B. GENERAL GOALS FOR IMPROVING SEISMIC SAFETY

Two major goals should be attained along with implementation of the Seismic Safety Element; an Earthquake Disaster Plan should be formulated, and a public awareness program initiated.

Earthquake Disaster Plan

An Earthquake Disaster Plan should be formulated which would enable each County and local community to be self-sufficient in the weeks following a severe earthquake, such as a magnitude 8.5 event on the San Andreas fault. The plan should take into account that road and rail transportation will probably be significantly reduced as a result of a severe earthquake. The public utilities (gas, electricity, and water) may be affected but to a lesser extent.

An Earthquake Disaster Plan should provide for emergency medical facilities, temporary shelter, emergency communications equipment, and emergency water and food supplies. Since a large earthquake will severely affect many cities and hundreds of thousands of people, the efforts of Federal and State emergency services will be severely overextended. It is advisable that each County be prepared to serve itself and maintain continued functioning of necessary services rather than expecting adequate aid from outside organizations.

CHAPTER

VII

TABLE VI

HAZARD COMPARISON OF NON-EARTHQUAKE-RESISTIVE BUILDINGS

Simplified Description of Structural Type	Relative Damageability (in order of increasing susceptibility to damage
Small wood-frame structures, i. e. dwellings not over 3,000 sq. ft. and not over 3 stories	1
Single or multistory steel-frame buildings with concrete exterior walls, concrete floors, and concrete roof. Moderate wall openings	1.5
Single or multistory reinforced-concrete buildings with concrete exterior walls, concrete walls, and concrete roof. Moderate wall openings	2
Large area wood-frame buildings and other wood frame buildings	3 to 4
Single or multistory steel-frame buildings with unreinforced masonry exterior wall panels; concrete floors and concrete roof	4
Single or multistory reinforced-concrete frame buildings with unreinforced masonry exterior wall panels, concrete floors and concrete roof	5
Reinforced concrete bearing walls with supported floors and roof of any material (usually wood)	5
Buildings with unreinforced brick masonry having sand-lime mortar; and with supported floors and roof of any material (usually wood)	7 & up
Bearing walls of unreinforced adobe, unreinforced hollow concrete block, or unreinforced hollow clay tile	Collapse hazard in moderate shocks

This table is intended for buildings not containing earthquake bracing, and in general, is applicable to most older construction. Unfavorable foundation conditions and/or dangerous roof tanks can increase the earthquake hazard significantly.

PUBLIC AWARENESS

A program to increase public awareness of earthquake safety should be initiated. The program could be presented as a series of County meetings or as individual community seminars. It should stress minimizing hazards in the home, and precautions to be taken after the occurrence of the earthquake. Appendix C (from California Geology, 1971) presents a comprehensive list of actions that an individual can take to minimize injury and loss in the event of an earthquake.

CHAPTER VII RELATIONSHIP TO GENERAL PLAN ELEMENTS

A. LAND USE

Based on the Technical Report and the structural evaluation there are no sections within the Five-County Study area in which a particu lar land use should be prohibited. Construction activity in the more critical seismic and secondary hazard zones would probably require additional capital costs to offset the increased seismic forces, but no area should be termed "off-limits" for specialized land uses, including critical facilities.

In general terms, the safest seismic zones correspond to the areas of greatest population. Zones V1 and S1 encompass virtually all the major population centers of the Five-County area. Several communities on the west side of the San Joaquin Valley fall within the most critical zones. Devil's Postpile National Monument occurs in Zone S4.

The Technical Report indicates that the areas of greatest acceleration are on the western side of the San Joaquin Valley and immediately abutting the slopes of the Coastal Mountain Range. While these seismic conditions do not necessarily preclude future urban development, it is fortunate that the greater amount of high-cost structures and high-density population centers are located at a considerable distance from both the San Andreas fault and the Owens Valley fault system. General Plans in the Five-County area forecast a continuation of the present land use characteristics. Based on seismic considerations, the present distribution of land uses appears most appropriate. Were new development to occur in the most critical zones there is undoubtedly the possibility that in the event of a major earthquake the structures would be put to a considerable test with the probability that many would incur severe structural damage. In general, continuation of present land use locational policies will serve to minimize the potential capital and associated human losses.

The Technical Report has dealt with the major faults in the study area. Other lesser faults do exist. These are far less important than any of the major faults examined. Most of these lesser faults are of short length and of little consequence beyond the immediate vicinity of the fault. As the location and dimensions of these faults become known from future detailed studies, new construction should not be placed immediately atop or astride the faults. It should be the responsibility of the County Departments of Building and Safety to establish a reasonable building setback distance based upon future detailed studies.

B. HOUSING

Findings of the study indicate there should be no restrictions placed on the location or type of single-family housing within the Five County area based on the analysis of the response spectra in the Technical Report. Regardless of building height, the most critical zones (V4 primarily) will experience shaking. The less critical areas, in an 8.5 Richter earthquake on the San Andreas fault, will experience less shaking with lower frequency shock waves. The taller structures will; however, be more impacted than the lower storied structures.

The same provisions specified in the discussion of Land Use regarding construction on known faults should, of course, also apply to the Housing Element.

C. CIRCULATION

Major restrictions on circulation systems are not indicated upon review of the response spectra in the Technical Report. Interstate 5 and Highway 99 are the principal vehicular systems within the study area. Of significance, Interstate 5 is encompassed within Zone V4 along its route in southwestern Kings County and southwestern Fresno County (paralleling the main San Andreas fault line). The failure of any section of this system would be a significant impact not only on the total circulation within the Five County area, but also on the movement of goods and people between northern and southern California. At the first opportunity it is recommended that Caltrans review the Technical Report for any possible impacts on Interstate 5.

Highway 99 is located in its entire route within Zone V1. If additional design work is considered on this system, it is recommended that the response spectra for Zone V1 be reviewed for applicability prior to finalization of design plans.

All other highway construction projects should include as part of the design effort a review of this report, particularly when the question of tunnel or bridge construction is involved.

Many railways are located throughout the Five County area. Again, special restrictions are not evidenced that would alter future or present alignment of these tract systems.

Airports display basically the same relationship to response spectra as do the railways.

D. OPEN SPACE

The usual major interrelationship between the Seismic Safety Element concerns the open space designation often applied to the area immediately astride a major fault. Since no major active fault lies within the Five County area, the open space implications of this element are minimal from this standpoint; however, significant geologic hazards do exist in terms of slope stability and settlement (Plate I) and some consideration of such hazard areas as open space can be justified.

E. SAFETY

The Seismic Safety Element is a major input to the Safety Element of the General Plan which is defined in the Government Code Section 65302.1 as follows:

> A safety element for the protection of the community from fires and geologic hazards including features necessary for such protection as evacuation routes, peak load water supply requirements, minimum road widths, clearances around structures, and geologic hazard mapping in areas of known geologic hazard.

No County within the study area has prepared a Safety Element of the General Plan. The preparation of the Safety Element will follow that of the Seismic Safety Element. Tulare County has completed an Environmental Resources Management Element.

CHAPTER

VIII

CHAPTER VIII PLAN UPDATE

Local governments utilizing this study and adopting Seismic Safety Elements must provide the updating and continuance mechanisms necessary for improving safety standards of their jurisdiction. As part of this process, a monitoring and surveillance system which utilizes information developed by the various state and federal agencies as well as colleges and special interest groups should be established. It is suggested that respective counties be responsible for working with these collectors to analyze information exchanges of importance and relay pertinent findings to interested cities for consideration. A formal mechanism such as the recommended County Seismic Committee could facilitate this coordination.

The Technical Report suggests that further or other additional studies are necessary or desirable. This is a part of plan update and information base expansion which should be considered for heuristic improvement of decision making related to Seismic Planning by local agencies. Certainly a program of major policy update every five years should be undertaken by each respective local government. In the event of a change in the base data caused by a major earthquake, it may be necessary to formulate a regional study group such as the existing Five-County Committee to reformulate or reconsider this plan and its implications.

CHAPTER

IX

APPENDICES

CHAPTER IX

APPENDIX A.

SAMPLE RESOLUTION

BEFORE THE
(NAME OF CITY OR COUNTY)
RESOLUTION NO.____

In the Matter of SEISMIC SAFETY PLANNING	)))))	RESOLUTION ADOPTING SEISMIC SAFETY ELEMENT OF GENERAL PLAN FOR (Name of City or County)

WHEREAS, the State of California Planning Law (Government Code Sec. 65302(F) requires that each county and city adopt a Seismic Safety Element of their General Plan Program,

NOW, THEREFORE, BE IT RESOLVED, that the (Name of City or County) adopts by reference the Five-County Seismic Safety Study with the following modifications (if any) as the Seismic Safety Element of the General Plan for the (Name of City or County) serving as a working document which will continually meet said requirement. (Document modifications)

THE FOREGOING RESOLUTION was passed and adopted by the (Name of City or County) this ____ day of _____, 1974.

AYES:

NOES:

ABSTAIN:

ABSENT:

Signed:_____
Name & Title

ATTEST:

I hereby certify that the foregoing is a true copy of a resolution of the (Name of City or County) duly adopted at a regular meeting thereof held on the ____ day of _____, 1974.

Signed:_____
Name & Title

APPENDIX B

DRAFT ENVIRONMENTAL IMPACT ASSESSMENT OUTLINES

TYPICAL COUNTY IMPACT ASSESSMENT OUTLINE

MODEL CITY ENVIRONMENTAL IMPACT ASSESSMENT OUTLINE

ENVIRONMENTAL IMPACT REPORT ON THE SEISMIC SAFETY ELEMENT FOR TULARE COUNTY

DESCRIPTION OF PROJECT:

The Seismic Safety Element for all City and County General Plans in the State of California is mandated by the State Legislature because of the real but difficult-to-predict peril of earth movements and the necessity to mitigate or dilute the attendant risk to public safety.

Section 65302(f) of the Governmental Code and the Council on Intergovernmental Relations guidelines give scope and direction for an Element. The Tulare County Seismic Safety Element recognizes these guidelines as important and has utilized them, but enlarged the scope where necessary to meet its goals. The Seismic Safety Element can be adopted as is or with modifications desired locally by various governments throughout the area.

DESCRIPTION OF EXISTING ENVIRONMENT:

Tulare County lies in the Southern half and on the east side of the San Joaquin Valley, the great central valley of California which is bounded on three sides by mountains -- the Coast Range to the west and the Sierra Nevadas to the east and south. The County itself covers approximately 4,863 square miles and encloses 3,112,320 acres. About one-fourth of the area is suitable for cultivation. The federal government owns 1,545,638 acres (49.6%) of which all but about 60,000 acres is public forest and recreation land. The 60,000 acres includes the Tule Indian Reservation (54,000 acres) and various canals and reservoirs. The State of California owns 26,436 acres (.8%) of which about 5,000 acres is in public forest. This amount of state and federal ownership means that only slightly under fifty per-cent of Tulare County land is under local control.

The valley lands are nearly level with very gentle to rolling slopes along the valley margins. Elevations range from sea level to about 500 feet. The foothill area is characterized by rolling to hilly relief and dissected by numerous streams flowing generally into the valley. They begin as terraces along the east edge of the valley floor, merge into gentle slopes, but rapidly become steep. "Foothill" elevations range from about 500 to 3,000 feet. The mountain area, with elevations from 3,000 to 14,495 feet (Mt. Whitney, highest point in the United States outside of Alaska) is characterized by hilly to steep mountains, with valleys at 3,000 to 7,000 feet.

The County contains land subject to slope instability and with high erosion potential; lesser amounts are subject to soil subsidence and liquefaction. The valley floor is underlain with thick alluvium deposits while the mountainous areas are underlain by large granite or other masses of varying texture, thickness and stability.

The central valley is a deep trough. Tulare County forms part of this trough filled with sediment deposited by the rivers from nearby mountains when the valley was part of a sea. Solidified granite lava that melted and manipulated previous rock layers lies beneath the Sierra Nevada which forms the easterly portion of the study area. Erosion and glaciers disinterred the granite until it became exposed in various locations. During the erosion and glaciation process, water carried sediments to the west.

According to the U.S. Soil Conservation Service, most of their soil classifications from 1 to 8 (except 5) are represented in Tulare County.

VALLEY BASIN SOILS:

Examples of principal crops are small grains, cotton, pasture, fruits, nuts, beets and dry beans.

Protection from flooding is important for Valley soils because they are usually poorly drained. Those portions having alkali and salt problems must undergo reclamation in order to be cultivated.

Alluvial Fans and Floodplain Soils:
Little or no conservation efforts are required for soils of these usually deep and well drained, non-saline or non-alkali soils. Erosion is no problem.

Low Terrace Soils:
When these are saline-alkali with hardpans, reclamation becomes difficult. Characterized by low fertility and moisture capacity.

Terrace Soils:
Shallow with low fertility and moisture capacity. Erosion is a problem. Well drained, sandy, wind modified soils. These are low in fertility and moisture capacity and have wind erosion problems.

Foothill Soils:
Principal crops are deciduous fruits and grains. These soils break into two basic types: shallow, well drained, slightly acid, stony or rocky medium textured upland or moderately deep to deep moderate coarse textured, well drained, slightly acid upland.

The shallow have conservation problems becuase of depth lack and rocks, but erosion is only slight if enough vegetation residue remains. The moderately deep to deep soils are low fertility and strongly tend to erode.

Sierra Nevada Soils:
The uses are usually recreation or lumbering with some grazing. This land is usually managed by the U. S. Forest Service and Bureau of Management. The soils are four general types. (Upland, intermediate elevations and are shallow to deep, medium to moderately fine texture.) The next is similar except that it is moderately deep to deep with moderate coarse texture. Upland soils of high elevations, shallow to moderately deep, coarse and moderately coarse textured, such as expanses of rockland on ridge crests and peaks. Alluvial soils of mountain valleys that are well to poorly drained, moderately coarse to moderately fine textured. The first two soils are low fertility, hilly to mountainous and erosion results when soils are disturbed. The shallower soils are handicapped by depth lack and low water-holding capacity. The mountain valley soils often have drainage problems, possibility of gullying and difficulty in growing desirable plants.

The major man made bodies of water are Lake Kaweah and Lake Success. Both are situated at the edge of foothills behind earth and rockfill dams with capacities (not counting flood surcharge spilling) of 8,000 to 150,000 acre feet for Kaweah and 9,000 to 82,000 acre feet for Success. The Friant-Kern Canal has a conveying average of 5,000 cubic second feet at the head which is the dam at Friant.

The California Department of Water Resources in reference to such dams, has stated the following:

> "In carrying out the intent of the statute to make every jurisdictional dam within California safe, we engage in a thorough engineering and geologic review of each site and the design and construction aspects of each dam before it is approved for construction. With regard to operational dams, we make at least one field inspection of each dam annually, and more frequently when circumstances require (such as after a major flood or significant earthquake).
>
> When a dam meets all safety requirements, a Certificate of Approval is issued by this Division approving the impoundment of water to the certified elevation. As long as the dam is operated within the requirements of the certificate, it is judged safe. In this respect, all approved dams under state jurisdiction within the counties of Tulare, Fresno, Kings, Madera, and Mariposa are deemed safe for operation within the conditions specified on each individual certificate. Seismic Safety is just one requirement which a dam must meet before it is approved."

BIOTA:

Endangered Species:
Blunt-Nosed Leopard Lizard
California Condor
Southern Bald Eagle
American Peregrine Falcon

Rare Species:
Giant Garter Snake
San Joaquin Kit Fox
Southern Wolverine
Kern Canyon Slender Salamander
California Bighorn Sheep

Special Concern:
California Slender Salamander
Golden Trout
Great Blue Heron
Tiger Salamander

There are many other species including coyote, hawks, snakes, rabbits, cats, rodents, etc.

There are five plant communities found in the County. Starting from the east is the Boreal Region including red fir-lodgepole pine forest, subalpine forest, alpine fell-fields. Next is the Yellow Pine Forest composed of mixed evergreens. Alongside is the foothill woodland and chaparral categorized as Foothills. The western most is Central Valley. The Sagebrush Scrub with pinion pine-juniper is the fifth.

The County has eight incorporated cities. Their urban area projected populations in 1973 were:*

Visalia	47,600
Porterville	27,450
Tulare	25,500
Dinuba	10,100
Lindsay	8,900
Exeter	5,800
Farmersville	4,400
Woodlake	4,000

Approximately 50 rural service centers, generally occurring at five mile intervals along arterials are found throughout the valley. In 1970, about 67 percent of the County residents were in urban densities; by 1990 a figure of 86 percent is anticipated.

Transportation is mainly by roads. State Highway 99 and Interstate 5 are the major transportation arteries and carry traffic in a north-south direction through the valley. The rugged heights of the Sierra Nevada preclude east-west highways in this area and access to this portion of the Sierra Nevada is limited. The area also has Amtrak, Southern Pacific and the Santa Fe Railroads. Visalia has regularly scheduled stops of commercial airlines. There are also several air fields serving private aircraft.

BACKGROUND OF THE SEISMIC STUDY:

This contract was entered into on behalf of the Five County Seismic Safety Committee by the Tulare County Association of Governments. The decision of the participating agencies requiring participation by both Policy and Technical Advisory Committees is a result of Resolution No. EC 73-16, passed by the California Council on Intergovernmental Relations at a meeting held on February 16, 1973, requiring as follows:

"1. A Technical Advisory Committee consisting of appropriate local planning and engineering staff shall be established to oversee the planning work and prepare recommendations for the Policy Advisory Committee.

2. A Policy Advisory Committee consisting of County Supervisors, City Councilmen and representatives of special districts must be established to oversee the project."

---

*Source: Population projection for Tulare County Urban Areas 1970-1995 - Tulare County Planning Department - November 1973.

In addition, since this is a project utilizing Federal Department of Housing and Urban Development funds, procedures were used for public participation as stated in the HUD requirements for Federal funding for local planning.

The following is a description of the public participation process as carried out on behalf of CPA 1032.17 contract:

> A total of 16 technical meetings have been held during the project. A total of 8 policy meetings have been held and continuous progress reporting has been undertaken at regular Tulare County Association of Government meetings, as well as other participating parties to the Five County Joint Powers Agreement. These meetings of the various agencies are held on a monthly basis and the Technical and Policy Committee Meetings of the Seismic Safety Committee have also generally been held on a monthly basis during the project period.

All meetings of the Technical Committees and Policy Committees have been held in places convenient to the public such as the City Hall at Fresno or Board of Supervisors room at Tulare County. All Committee meetings have been well attended by interested people. The results of these meetings and notices of these meetings have been periodically carried in local newspapers and the local newspapers have reported progress of the project at various times during the course of the project Meetings within each county have been held within Planning communities and other organized groups. Participants include Tulare County Association of Governments (as project manager), the Council of Fresno County Governments, the Kings County Regional Planning Agency, the Madera County Planning Department, and the Mariposa County Engineers Department.

The technical nature of the data suggested that an educational approach be taken to public participation and that, at certain points during the project where problems or solutions were evident, public participation should take place.

The mailing list for the project included 65 individuals and agencies from Federal to local agencies and interested citizen groups and committees. (For the Tulare County Element, the Agricultural Committee and the Environmental Quality Committee, consisting of some 90 people, have been involved and the TCAG Staff has reported progress to them at various times).

The general attendance includes Staff, elected officials, educators, engineers and other agency personnel. All have made contributions to the progress of the project and have been continuously involved from its conception. It should be noted that diverse opinions and perceptions or perspectives accounted for the inability of consultants staff to address every single question, however, the meetings provided a vehicle for understanding among people throughout the larger regional community. The consultants attempted, wherever possible, to address those comments that were most appropriate to the general philosophy that had been selected for preparing the reports.

There has been continuing interest in this project at a State-wide level and numerous pieces of correspondence have been received from other counties and cities attempting to do their own Seismic Safety Elements. The Project Director attended the conference on Seismic Safety Planning that was given in December by the Engineering Foundation Conference entitled "Community Planning for Seismic Safety" which was chaired by Walter W. Hays of the United States Geological Survey. The consultants also attended the conference and there was plenty of opportunity following the conference for the consultants and the Staff to review the overall direction of the program when changes were possible in the program.

As pointed out earlier, an educational approach to community involvement has been attempted in the project and will be a continuing effort in the implementation of the project. This implementation process must be carried out by each of the individual counties and councils of government involved in the program since this is one of the primary places where implementation is affected.

The Tulare County Planning Department Staff and the Council of Fresno County Governments have both prepared slide presentations for dissemination of information to the public. This information is available to any interested governmental agencies within the project area.

RELATIONSHIP TO GENERAL PLAN:

The Seismic Safety Element is a state-mandated element of the General Plan for every County and City. The attached Element meets all requirements of the adopted state guidelines promulgated by the California Council on Intergovernmental Relations. It protects from and mitigates the risks involved with environmental hazards related in particular to seismicity.

THE ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION:

These impacts are primarily beneficial to the environment of Tulare County in that the study will help planning and guide development to lessen the possibility of seismic damage to lives and environment. The uses of man's environment and the maintenance and enhancement of long-term productivity would be served by this project.

There will be little if any physical change or alteration to ecological systems caused by the plan element. However, there may be inherent in the seismic study long-term changes in proposed population distribution, population concentration and the human use of land, in that an area with lower potential seismic danger may be encouraged to grow as compared to areas of greater danger. In other words, the population growth may be lessened in the long-term in some parts of the study area. The flat valley region that characterizes much of Tulare County will possibly draw people and activities concerned with the avoidance of seismic hazards from areas of the State which have a history and potential of such hazards.

For example, residents of the San Francisco, Los Angeles and other heavily populated areas may be drawn to the San Joaquin Valley. More caution should be exercised in building in those parts of Tulare County that are exposed to seismic hazards.

ANY ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED IF THE PROPOSAL IS IMPLEMENTED:

1. The possibility of increased population growth for flat areas may accelerate removal of increasing amounts of high quality Tulare County agricultural land from productivity. This possibility of increased population growth, if too sudden, may increase the demand for urban services such as utilities including gas, water, waste disposal, telephone, and other services and facilities such as schools, police and fire protection, etc. Accompanying increased air pollution will further curtail agricultural productivity and injure humans and wildlife. This factor of air pollution is very important to Tulare County because atmospheric conditions include inversion layers which have already trapped air pollutants emanating from outside areas.

2. Tulare County may appear more attractive to industries and uses that involve hazards. Possible examples of such are nuclear operations, manufacture and storage of dangerous materials, and other unforeseen activities that may offer possibilities of accidental environmental damage. It must be noted that the County has in the past been selected as a potential site for those uses.

MITIGATION MEASURES PROPOSED TO MINIMIZE THE IMPACT:

The project in itself proposes mitigation of potential impacts on the environment, on man and his works. The information contained and the possible applications are such that human activities will be more likely to be distributed within the County in such a fashion that the seismic hazards to human life and environment will be lessened.

ALTERNATIVE TO THE PROPOSED ACTION:

1. No project. This would allow the continued uneducated exposure of man and his works to seismic hazards.

2. Delay the project. This would have effects similar to no project until a decision to allow the project is reached.

3. Allow the project. This offers opportunities for planning in order to channel man's activities in such a way that potential seismic hazards to life and environment would be mitigated.

THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY:

The cumulative effects have been touched on before. There will be a tendency for man and his activities to move from areas of high seismic hazard such as Los Angeles, San Francisco and other coastal areas to relatively safer areas such as the nearly flat portion of Tulare County. Both long and short term uses of man's environment will find applications for the study.

This study does not pose long-term risks to health or safety but on the contrary will serve to mitigate such risks. There will not be narrowing of the beneficial uses of the environment because uses will be placed in areas where they will be in less jeopardy and at the same time offer less environmental and ecological hazard.

However, there is the increase in possibilities of attracting greater population and potentially hazardous activities as mentioned in other portions of this report.

This project is justified now. Seismic hazards exist in portions of the County and the sooner seismic planning commences, the sooner the amelioration of such hazards can begin, which means possible saving of human life and the maintenance and enhancement of the long-term productivity of man's environment in a safer way.

ANY IRREVERSIBLE ENVIRONMENTAL CHANGES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED:

The changes of population growth, and other impacts discussed elsewhere in this report are for practical purposes usually irreversible. The environmental changes brought about by seismic events that are unplanned and hence unprepared for are likewise irreversible.

However, any lives or parts of man's environment or productivity that could be preserved can by the same token be considered from a practical point of view as irreversible. In general, environmental accidents would be mitigated, but again there is the prospect of invitation of people and hazardous activities to the portions of the County which are relatively free of seismic concerns.

GROWTH INDUCING IMPACT OF THE PROPOSED ACTION:

There is a definite spur to population growth for the relatively less hazardous areas at the expense of present or potential high population areas. As was indicated before, population from the urban and coastal mountain areas are apt to be drawn to safer areas such as those in Tulare County, with the accompanying problems of increased pressures on the environment and the provision of urban type services. Possibilities of drawing hazardous industries and activities has been discussed previously in this report.

APPROVED BY _____
ENVIRONMENTAL REVIEW COMMITTEE

_____
DATE

_____
REVIEW PERIOD

TULARE COUNTY PLANNING DEPARTMENT

POLICY DOCUMENTS AND REFERENCES USED IN E.I.R.

(1) Animal Waste, Tulare County Planning Department, (as yet unadopted).

(2) At the Crossroads, Department of Fish and Game, 1974.

(3) Biological Resources, Tulare County Planning Department, (as yet unadopted)

(4) California County Fact Book, 1973.

(5) California Outdoor Recreation Resource Plan, State of California, Dept. of Parks and Recreation, January, 1974.

(6) Central Valley Report.

(7) Comprehensive Framework Study, California Region, USDA Soil Conservation Service, May, 1972.

(8) Eastern Fresno Area Soil Survey, California Department of Agriculture, 1967

(9) Environmental Resources Management Element, Tulare County Planning Departme 1970: Open Space, Recreation, Conservation

(10) Five County Seismic Safety Element, Part I, Technical Report - Johns, et al First Draft, January, 1974.

(11) Five County Seismic Safety Element, Part II, Summary & Policy Recommendatio Five County Seismic Safety Committees, First Draft, March, 1974.

(12) General Plan, Tulare County Planning Department, 1963.

(13) Rare and Endangered Species Habitat Map, Grunwald, Crawford, and Associates 1973.

(14) San Joaquin Valley Basin, USDA River Basin Study Soil Group Areas, 1972.

(15) Sierra Nevada, Verna R. Johnston, Houghton Mifflin Co., 1970.

(16) Letter to Tulare County Planning Department from Department of Water Resources - dated April 15, 1974.

MODEL
ENVIRONMENTAL IMPACT REPORT ON THE SEISMIC SAFETY ELEMENT FOR CITIES OF FRESNO, KINGS MADERA, MARIPOSA AND TULARE COUNTIES

DESCRIPTION OF IMPACT:

A Seismic Safety Element for all city and County general plans is mandated in the State of California because of the real, but difficult-to-predict peril of earth movements. It must contain background technical information and policies generated therefrom which will ameliorate the risk from such hazards.

Section 65302(f) of the Government Code, and the Council on Intergovernmental Relations guidelines give scope and direction for such an element. Since this is regional problem (Owens Valley fault group and the San Andreas fault flank the five county study area), the counties of Fresno, Kings, Madera, Mariposa and Tulare joined together to study the regional aspects of seismicity and propose policies for the protection of public health and safety. This Element, now adopted by the City of_____ will meet the requirements of the planning law.

DESCRIPTION OF ENVIRONMENTAL SETTING:

The City of_____ is located_____
_____
in the County of_____. The areawide setting encompasses most of the southern half of the San Joaquin Valley, extending to the crest of the Sierra Nevada Range. (This is the great central valley of California which is bounded on three sides by mountains -- the Coast Range to the west and the Sierra Nevadas to the east and south). The City of _____ covers approximately _____ acres of the _____ acres comprising _____ County.

The City of _____, with a population of_____ within the City limits, and an urban area population of _____, is an urban node within the County, whose chief income derives from, _____
_____. Its urban lands are a combination of residential, commercial and manufacturing locations, with approximately _____ % residential, _____ % commercial and _____ % manufacturing uses. Public and recreational uses make up the bulk of the remaining land within the city limits, with large amounts of the area between the city limits and the Urban Area Boundary being largely uncomitted at this time, while being reserved for the future urban uses.

The physical environment of the City is unique/typical in that it is situated on topography, soils, hydrological characteristics (rivers, lakes, etc.) and has climate which averages _____ degrees in summer and _____ degrees in winter. Rainfall averages _____ inches per year. It derives its water supply from _____ (wells/surface) supplies and has a (community/no community) sewer system.

Because of its urban nature, the protection of endangered species is of little consequence; there are few places for wildlife in the vicinity. Flora are largely transplanted from native situations, again because of the urban scene.

Transportation is mainly by roads. The major transportation arteries serving this community are State/Federal highways and several large arterials of note within the city are _____. _____, Railroads provide freight service, as well as several large trucking concerns. Bus service is (limited/good) and commercial airlines have regularly scheduled stops at _____ which is _____(relationship/location). Private aircraft may use _____(airfield/s) nearby. (Any major gas pipe lines, oil pipe lines, etc. should be mentioned here).

The present and future populations for the five counties are as follows: 756,000[2] for 1973 and 898,000[3] for 1985.

BACKGROUND OF THE SEISMIC STUDY:

This contract was entered into on behalf of the Five County Seismic Safety Committee by the Tulare County Association of Governments. The decision of the participating agencies requiring participation by both Policy and Technical Advisory Committees is a result of Resolution No. EC 73-16, passed by the California Council on Intergovernmental Relations at a meeting held on February 16, 1973, requiring as follows:

"1. A Technical Advisory Committee consisting of appropriate local planning and engineering staff shall be established to oversee the planning work and prepare recommendations for the Policy Advisory Committee.

2. A Policy Advisory Committee consisting of County Supervisors, City Councilmen and representatives of special districts must be established to oversee the project."

2 California Finance Department, Budget Division, "Provisional Projections of California Counties to 2,000."

3 California County Fact Book, 1973, California Government Education Foundation.

In addition, since this is a project utilizing Federal Department of Housing and Urban Development funds, procedures were used for public participation as stated in the HUD requirements for Federal funding for local planning.

The following is a description of the public participation process as carried out on behalf of CPA 1032.17 contract:

> A total of 16 technical meetings have been held during the project. A total of 8 policy meetings have been held and continuous progress reporting has been undertaken at regular Tulare County Association of Government meetings, as well as meetings of the other participating parties to the Five County Joint Powers Agreement. These meetings of the various agencies were held monthly and the Technical and Policy Committee Meetings of the Seismic Safety Committee have also generally been held on a monthly basis during the project period.
>
> The City of _____ was represented in the Policy Committee by (agency) _____.

All meetings of the Technical Committees and Policy Committees have been held in places convenient to the public such as the City Hall at Fresno or Board of Supervisors room at Tulare County. All Committee meetings have been well attended by interested people. The results of these meetings and notices of these meetings have been periodically carried in local newspapers and the local newspapers have reported progress of the project at various times during the course of the project. Meetings within each county have been held within (planning agencies) and by other organized groups. Participants include Tulare County Association of Governments (as project manager), the Council of Fresno County Governments, the Kings County Regional Planning Agency, the Madera County Planning Department, and the Mariposa County Engineering Department.

The technical nature of the data suggested that an educational approach be taken to public participation and that, at certain points during the project where problems or solutions were evident, public participation should take place.

The mailing list for the project included 65 individuals and agencies from Federal to local agencies and interested citizen groups and committees. (For the Tulare County efforts, the Agricultural Committee and the Environmental Quality Committee, consisting of some 90 people, have been involved and the TCAG Staff has reported progress to them at various times.)

The general attendance included staff, elected officials, educators, engineers and other agency personnel. All have made contributions to the progress of the project and have been continuously involved from its conception. It should be noted that diverse opinions and perceptions or perspectives accounted for the inability of consultants staff to address every single question, however, the meetings provided a vehicle for understanding among people throughout the larger regional community. The consultants attempted, wherever possible, to address those comments that were most appropriate to the general philosophy that had been selected for preparing the reports.

There has been continuing interest in this project at a State-wide level and numerous pieces of correspondence have been received from other counties and cities cities attempting to do their own Seismic Safety Elements. The Project Director

2. The area may (or may not) attract industries and uses that involve hazards. Possible examples of such are nuclear operations, manufacture and storage of dangerous materials, and other unforeseen activities that may offer possibilities of accidental environmental damage.

3. Increased population may, in addition, excessively burden local natural resources such as water, land, air and energy distribution so as to lower the present quality of life.

MITIGATION MEASURES PROPOSED TO MINIMIZE THE IMPACT:

1. The project in itself is a mitigation of potential impacts on the environment. The information contained and the possible applications are such that human activities will be more likely to be distributed in such a fashion that the seismic hazards to human life and environment will be lessened.

2. The General Plan can so confine and direct new population growth as to continue to protect agricultural productivity, as well as local natural resources, if need be.

ALTERNATIVES TO THE PROPOSED ACTION:

1. No project. This would allow the continued exposure of man and his environment to seismic hazards.

2. Delay the project. This would have effects similar to no project and would result in additional expenses to the City of _____ which is attempting to meet State requirements.

3. Allow the project. This offers opportunities for planning in order to channel man's activities in such a way that potential seismic hazards to life and environment would be mitigated.

THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY:

The cumulative effects have been touched on before. There will be a tendency for man and his activities to move from areas of high seismic hazard such as Los Angeles, San Francisco and other coastal areas to relatively safer areas such as the San Joaquin Valley which forms a large portion of the five county area. Both long and short term uses of man's environment will find applications for the study.

This study does not pose long-term risks to health or safety, but on the contrary will serve to mitigate such risks, as they are seismically related. There will not be narrowing of the beneficial uses of the environment because uses will be placed in areas where they will be in less jeopardy and at the same time offer less environmental and ecological hazard.

However, for the city area there is the increase in possibilities of attracting potentially hazardous activities as mentioned in the adverse effects portion of this report.

attended the conference on Seismic Safety Planning that was given in December by the Engineering Foundation Conference entitled "Community Planning for Seismic Safety" which was chaired by Walter W. Hays of the United States Geological Survey. The consultants also attended the conference and there was plenty of opportunity following the conference for the consultants and the staff to review the overall direction of the program when changes were possible in the program.

As pointed out earlier, an educational approach to community involvement has been attempted in the project and will be a continuing effort in the implementation of the project. This implementation process will be carried out by the City of _____ since this is one of the primary areas where implementatio is affected.

The Tulare County Planning Department Staff and the Council of Fresno County Governments have both prepared slide presentations for dissemination of information to the public. This information is available to any interested governmental agency within the project area, and the City of _____ may utilize this information as support for its community involvement effort.

RELATIONSHIP TO GENERAL PLAN:

The Seismic Safety Element is a State-mandated element of the General Plan for every County and City. The attached Element meets all requirements of the adopted State Guidelines promulgated by the California Council on Intergovernmental Relations. It protects from and mitigates the risks involved with environmental hazards related in particular to seismicity.

THE ENVIRONMENTAL IMPACT OF THE PROPOSED ACTION:

These impacts are primarily beneficial to the environment in that the study will help planning to lessen the possibility of seismic damage to lives and environment, particularly, the uses of man's environment and the maintenance and enhancement of long-term productivity.

There will be little if any physical changes, or alterations to ecological systems caused by the study. However, there may be inherent in the study long-term changes in proposed population distribution, population concentration and the human use of land and structures in that certain areas with lower potential seismic danger will be encouraged to grow as compared to areas of great danger.

The City of _____ anticipates that some additional growth (may or may not) occur as a result of the study.

ANY ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED IF THE PROPOSAL IS IMPLEMENTED:

1. The possibility of increased population growth for flat areas may accelerate removal of increasing amounts of high quality agricultural land from productivity. This possibility of increased population growth, if too sudden, may burden the present public facilities such as transportation, housing, police and fire protection, utility systems, schools and so forth, as well as increase living costs for present residents. Accompanying increased air and water pollution will further curtail agricultural productivity and injure humans.

This project, because of its potential benefits as stated previously in the report, is justified now because seismic hazards exist and the sooner planning is started to ameliorate such hazards, the better for man and the maintenance and enhancement of the long-term productivity of his environment.

In addition, the project will provide the city with parameters for policy planning, based upon scientifically sound information.

ANY IRREVERSIBLE ENVIRONMENTAL CHANGES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED:

The changes in population growth, and other impacts discussed elsewhere in this report are for practical purposes usually irreversible. The environmental changes brought about by seismic events that are unplanned and hence unprepared for are likewise irreversible.

However, any lives or parts of man's environment or productivity that could be preserved can, by the same token be considered from a practical point of view as irreversible. In general, environmental accidents would be mitigated, but again, there is the prospect of invitation of people and hazardous activities to portions of the five county area.

GROWTH INDUCING IMPACT OF THE PROPOSED ACTION:

There is (is not) a definite spur to population growth for the city. As was indicated before, population from the urban coastal mountainous areas are apt to be drawn to safer areas with the accompanying problems of increased pressures on the environment and the City of _____ could be affected.

The possibility of attracting certain industries and activities has been discussed previously in this report.

Respectfully submitted,

Approved by_____
ENVIRONMENTAL REVIEW COMMITTEE

_____
DATE

_____
REVIEW PERIOD

(When and if this is completed by a city, it should be transmitted to the Environmental Review Committee of the County Planning Department.)

POLICY DOCUMENTS AND REFERENCES USED IN E.I.R.

(1) Animal Waste, Tulare County Planning Department, (as yet unadopted).

(2) At the Crossroads, Department of Fish and Game, 1974

(3) Biological Resources, Tulare County Planning Department, (as yet unadopted).

(4) California County Fact Book, 1973.

(5) California Outdoor Recreation Resource Plan, State of California, Dept. of Parks and Recreation, January, 1974.

(6) Central Valley Report.

(7) Comprehensive Framework Study, California Region, USDA Soil Conservation Service, May, 1972.

(8) Eastern Fresno Area Soil Survey, California Department of Agriculture, 1967.

(9) Environmental Resources Management Element, Tulare County Planning Department, 1970: Open Space, Recreation, Conservation

(10) First Draft - Parts I & II - Five County Seismic Safety Committee, 1974.

(11) General Plan, Tulare County Planning Department, 1963.

(12) Rare and Endangered Species Habitat Map, Grunwald, Crawford, and Associates, 1973.

(13) San Joaquin Valley Basin, USDA River Basin Study Soil Group Areas, 1972.

(14) Sierra Nevada, Verna R. Johnston, Houghton Mifflin Co., 1970.

(15) Letter to Tulare County Planning Department from Department of Water Resources - dated April 15, 1974.

POLICY DOCUMENTS AND REFERENCES USED IN E.I.R.

(1) Antioch Master, Solano County Planning Commission, (as yet unadopted).

(2) At the Crossroads, Department of Water and Land, 1974

(3) Biological Resources, Solano County Planning Department, (as yet unadopted).

(4) Solano County Plan Book, 1973.

(5) The Sacramento Regional Transportation Plan, State of California, Dept. of Public and Environmental Planning, 1974.

(6) Various Planning Studies.

(7) Transportation Framework Study, Sacramento Regional Area Planning Commission, Sacramento, May, 1972.

(8) Solano Transportation Study Summary, California Department of Architecture, 1967.

(9) Environmental Impacts Analysis Report, Solano County Planning Department (Jim Spoon, Jerry Cohen, Consultants).

(10) Study Area - Series 1 & II - Area Source Analysis Report, Dept. of Transportation, 1974.

(11) General Plan, Solano County Planning Department, 1969.

(12) Air and Emissions Inventory Vehicles Mon, Consult. Stanford Res. Inst. Air Conservation, 1971.

(13) Air Pollution Control Laws, Bill Rinner Water Board Cross Acres, 1973

(14) Starve Bonds, Verne F. Johnson, Production Marketing Co., 1970.

(15) Letter to Solano County Planning Department from Department of Fish Resources - dated April 23, 1974.

APPENDIX C

EARTHQUAKE SAFETY PROCEDURES

EARTHQUAKE SAFETY PROCEDURES

BEFORE AN EARTHQUAKE

1. Potential earthquake hazards in the home should be removed or corrected. Top-heavy objects and furniture, such as bookcases and storage cabinets, should be fastened to the wall and the largest and heaviest objects placed on lower shelves. Water heaters and other appliances should be firmly bolted down, and flexible connections should be used whenever possible.

2. Supplies of food and water, a flashlight, a first-aid kit, and a battery-powered radio should be set aside for use in emergencies. Of course, this is advisable for other types of emergencies, as well as for earthquakes.

3. One or more members of the family should have a knowledge of first aid procedures because medical facilities nearly always are overloaded during an emergency or disaster, or may themselves be damaged beyond use.

4. All responsible family members should know what to do to avoid injury and panic. They should know how to turn off the electricity, water, and gas; and they should know the locations of the main switch and valves. This is particularly important for teenagers who are likely to be alone with smaller children.

5. It is most impportant for a resident of California to be aware that this is "earthquake country" and that earthquakes are most likely to occur again where they have occurred before. Building codes that require earthquake-resistant construction should be vigorously supported and, when enacted into law, should be rigorously enforced. If effective building codes and grading ordinances do not exist in your community, support their enactment.

DURING AN EARTHQUAKE

1. The most important thing to do during an earthquake is to remain calm. If you can do so, you are less likely to be injured. If you are calm, those around you will have a greater tendency to stay calm, too. Make no moves or take no action without thinking about the possible consequences. Motion during an earthquake is not constant; commonly, there are a few seconds between tremors.

2. If you are inside a building, stand in a strong doorway or get under a desk, table, or bed. Watch for falling plaster, bricks, light fixtures, and other objects. Stay away from tall furniture, such as china cabinets, bookcases, and shelves. Stay away from windows, mirrors, and chimneys. In tall buildings, it is best to get under a desk if it is securely fastened to the floor, and to stay away from windows or glass partitions.

3. Do not rush outside. Stairways and exits may be broken or may become jammed with people. Power for elevators and escalators may have failed. Many of the 115 persons who perished in Long Beach and Compton in 1933 ran outside only to be killed by falling debris and collapsing chimneys. If you are in a crowded place such as a theater, athletic stadium, or store, do not rush for an exit because many others will do the same thing. If you must leave a building, choose your exit with care and, when going out, take care to avoid falling debris and collapsing walls or chimneys.

4. If you are outside when an earthquake strikes, try to stay away from high buildings, walls, power poles, lamp posts, or other structures that may fall. Falling or fallen electrical power lines must be avoided. If possible, go to an open area away from all hazards but do not run through the streets. If you are in an automobile, stop in the safest possible place, which, of course, would be an open area, and remain in the car.

AFTER AN EARTHQUAKE

1. After an earthquake, the most important thing to do is to check for injuries in your family and in the neighborhood. Seriously injured persons should not be moved unless they are in immediate danger of further injury. First aid should be administered, but only by someone who is qualified.

2. Check for fires and fire hazards. If damage has been severe, water lines to hydrants, telephone lines, and fire alarm systems may have been broken; contacting the fire department may be difficult. Some cities, such as San Francisco, have auxiliary water systems and large cisterns in addition to the regular system that supplies water to fire hydrants. Swimming pools, creeks, lakes, and fish ponds are possible emergency sources of water for fire fighting.

3. Utility lines to your house - gas, water, and electricity - and appliances should be checked for damage. If there are gas leaks, shut off the main valve which is usually at the gas meter. Do not use matches, lighters, or open-flame appliances until you are sure there are no gas leaks. Do not use electrical switches or appliances if there are gas leaks, because they give off sparks which could ignite the gas. Shut off the electrical power if there is damage to the wiring; the main switch usually is in or next to the main fuse or circuit breaker box. Spilled flammable fluids, medicines, drugs, and other harmful substances should be cleaned up as soon as possible.

4. Water lines may be damaged to such an extent that the water may be off. Emergency drinking water can be obtained from water heaters, toilet tanks, canned fruits and vegetables, and melted ice cubes. Toilets should not be flushed until both the incoming water lines and outgoing sewer lines have been checked to see if they are open. If electrical power is off for any length of time, plan to use the foods in your refrigerator and freezer first before they are spoiled. Canned and dried foods should be saved until last.

5. There may be much shattered glass and other debris in the area, so it is advisable to wear shoes or boots and a hard hat if you own one. Broken glass may get into foods and drinks. Liquids can be either strained through a clean cloth such as a handkerchief or decanted. Fireplaces, portable stoves, or barbecues can be used for emergency cooking but the fireplace chimney should be carefully checked for cracks and other damages before being used. In checking the chimney for damage, it should be approached cautiously, because weakened chimneys may collapse with the slightest of aftershocks. Particular checks should be made of the roof line and in the attic because unnoticed damage can lead to a fire. Closets and other storage areas should be checked for objects that have been dislodged or have fallen, but the doors should be opened carefully because of objects that may have fallen against them.

6. Do not use the telephone unless there is a genuine emergency. Emergencies, and damage reports, alerts, and other information can be obtained by turning on a battery operated radio. Do not go sightseeing; keep the streets open for the passage of emergency vehicles and equipment. Do not speculate or repeat the speculations of others - this is how rumors start.

7. Stay away from beaches and other waterfront areas where seismic sea waves (tsunamis), sometimes called "tidal waves," could strike. Again, your radio is the best source of information concerning the likelihood that a seismic sea wave will occur. Also stay away from steep landslide-prone areas if possible, because aftershocks may trigger a landslide or avalanche, especially if there has been a lot of rain and the ground is nearly saturated. Also stay away from earthquake-damaged structures. Additional earthquake shocks known as "aftershocks" normally occur after the main shock, sometimes over a period of several months. These are usually smaller than the main shock but they can cause damage, too, particularly to damaged and already weakened structures.

8. Parents should stay with young children who may suffer psychological trauma if parents are absent during the occurrence of aftershocks.

9. Cooperate with all public safety and relief organizations. Do not go into damaged areas unless authorized; you are subject to arrest if you get in the way of, or otherwise hinder, rescue operations. Martial law has been declared in a number of earthquake disasters. In the 1906 disaster in San Francisco, several looters were shot.

10. Send information about the earthquake to United States Governmental Survey, Seismic Engineering Branch, Menlo Park, California, telephone (415) 323-8111 to help earth scientists understand earthquakes better.

APPENDIX D

CRITICAL FACILITIES INDEX & LISTINGS

CRITICAL FACILITIES

Critical Facilities are identified by county, range and township as related to the Mount Diablo Base and Meridian. The index describes location of facilities and indicates the nearest community. The number assigned to the general location of critical facilities is then used to locate the list of those facilities immediately following the index.

The listing is not all inclusive. The intent here is to provide each community in the study area with at least a minimum list of those facilities considered by the committees to be "critical." Critical is defined as the necessity for certain structures and facilities to continue functioning during or immediately after an earthquake.

Each community may wish to make additions or deletions from the list as they deem necessary.

FRESNO COUNTY

Index of Critical Facilities

Location Index	Area/Facility
1	T 12S, R 26E: Balch Afterbay
2	T 12S, R 27E: Balch Diversion
3	T 07S, R 27E: Bear Creek Diversion Florence Lake Portal Power House Forebay
4	T 08S, R 25E: Big Creek No. 4 Compton Sub-Station Huntington Lake Elementary Schools (2)
5	T 08S, R 24E: Big Creek No. 5 Big Creek No. 6
6	T 09S, R 23E: Big Creek No. 7
7	T 10S, R 28E: Courtright Dam
8	T 13S, R 23E: Giffen Reservoir
9	T 07S, R 24E: Mammoth Pool
10	T 13S, R 15E: Mendota Diversion
11	T 06S, R 27E: Mono Creek Diversion Vermillion Valley Dam
12	T 13S, R 22E: Redbank Dam
13	T 17S, R 21E: Reynolds Weir
14	T 14S, R 27E: Sequoia Lake Dunlop Sub-Station
15	T 09S, R 24E: Shaver Lake
16	T 17S, R 18E: Stinson Weir
17	T 11S, R 27E: Wishon Dam
18	T 12S, R 21E: Big Dry Creek Dam Coppermine Sub-Station
19	T 11S, R 21E: Friant Dam
20	T 13S, R 28E: Hume Lake
21	T 13S, R 11E: Little Panoche Diversion
22	T 13S, R 24E: Pine Flat Dam Tivy Valley Sub-Station
23	Dos Palos
24	Firebaugh
25	Mendota
26	Tranquillity
27	San Joaquin
28	Helm
29	Cantua Creek
30	Five Points
31	Huron
32	Coalinga
33	Joaquin Ridge
34	Riverdale
35	Burrell
36	Caruthers
37	Raisin City
38	Kerman
39	Biola
40	Herndon
41	Highway City
42	Easton
43	Malaga
44	Fowler
45	Selma
46	Kingsburg
47	Laton
48	Conejo
49	Monmouth
50	Reedley
51	Parlier
52	Del Rey
53	Sanger
54	Fresno
55	Clovis
56	Auberry
57	Tollhouse
58	Navelencia
59	Orange Cove
60	Miramonte
61	Balch Camp
62	Centerville
63	Coalinga Sub-Station No. 2
64	Asbestos Sub-Station
65	Califax Electric Sub-Station
66	Cantua Electric Sub-Station
67	Westlands Electric Sub-Station
68	Panoche Electric Sub-Station
69	Kearney Electric Sub-Station
70	Silver Creek
71	Oro Loma
72	Line Creek Electric Sub-Station
73	Pinedale

FRESNO COUNTY

List of Critical Facilities

Location Index	Community/Facility
1	T 12S, R 26E: Balch Afterbay
2	T 12S, R 27E: Balch Diversion
3	T 07S, R 27E: Bear Creek Diversion Florence Lake Portal Power House Forebay
4	T 08S, R 25E: Big Creek No. 4 Compton Sub-Station Huntington Lake 1 Elementary Schools (2)
5	T 08S, R 24E: Big Creek No. 5 Big Creek No. 6
6	T 09S, R 23E: Big Creek No. 7
7	T 10S, R 28E: Courtright Dam
8	T 13S, R 23E: Giffen Reservoir
9	T 07S, R 24E: Mammoth Pool
10	T 13S, R 15E: Mendota Diversion

11 T 06S, R 27E: Mono Creek Diversion
Vermillion Valley Dam
12 T 13S, R 22E: Redbank Dam
13 T 17S, R 21E: Reynolds Weir
14 T 14S, R 27E: Sequoia Lake
Dunlop Sub-Station
15 T 09S, R 24E: Shaver Lake
16 T 17S, R 18E: Stinson Weir
17 T 11S, R 27E: Wishon Dam
18 T 12S, R 21E: Big Dry Creek Dam
Coppermine Sub-Station
19 T 11S, R 21E: Friant Dam
Elementary School (1)
Fire Station (1)
20 T 13S, R 28E: Hume Lake
21 T 13S, R 11E: Little Panoche Diversion
22 T 13S, R 24E: Pine Flat Dam
Tivy Valley Sub-Station
23 DOS PALOS
Sheriff Sub-Station
High School (1)
Elementary Schools (3)
Dos Palos Electric Sub-Station
24 FIREBAUGH
Elementary Schools (3)
Las Deltas Grammar School
Fire Station
Southern Pacific Railroad
25 MENDOTA
Elementary Schools (3)
Fire Station
Police Department
City Hall
Southern Pacific Railroad
Mendota Electric Sub-Station
26 TRANQUILLITY
High School (1)
Elementary School (1)
Fire Station
Continuation School (1)
Southern Pacific Railroad
27 SAN JOAQUIN
Elementary School (1)
City Hall
Fire Station
San Joaquin Electric Sub-Station
Southern Pacific Railroad
28 HELM
Elementary School (1)
Southern Pacific Railroad
Stroud Electric Sub-Station
Valley Nitrogen Electric Sub-Station
Helm Electric Sub-Station
29 CANTUA CREEK
Elementary School (1)
Giffen Electric Sub-Station
Chenery Electric Sub-Station
30 FIVE POINTS
Elementary School (1)
Five Points Health Center
Schindler Electric Sub-Station
31 HURON
Elementary School (1)
City Hall
Jail-Police Department
Southern Pacific Railroad
Gates Electric Sub-Station
Huron Electric Sub-Station
32 COALINGA
Elementary School
Community College
California Highway Patrol Office
Airport
District Hospital
Sheriff Sub-Station
City Hall
Fire Department
Water Works
Southern Pacific Railroad
Radio Station - KOLI
Coalinga Electric Sub-Station No. 1
33 JOAQUIN RIDGE
Microwave Repeater
34 RIVERDALE
Elementary Schools (2)
High School (1)
Southern Pacific Railroad
Fire Station
Camden Electric Sub-Station
35 BURRELL
Elementary School (1)
Caruthers Electric Sub-Station
36 CARUTHERS
High School (1)
Elementary School (1)
Honor Farm
Fire Station
37 RAISIN CITY
Day Care Center
Elementary School (1)
38 KERMAN
Elementary Schools (3)
High School (1)
Police Department
Fire Station
Justice Court
Sewage Treatment Plan
Kerman Community Center
Old City Hall
Kerman Electric Sub-Station
Southern Pacific Railroad
39 BIOLA
Elementary School
Sun - Empire School
Fire Station
Biola Electric Sub-Station
Southern Pacific Railroad
40 HERNDON
Elementary School (1)
Southern Pacific Railroad
Herndon Electric Sub-Station
41 HIGHWAY CITY
Elementary School (1)
Southern Pacific Railroad
42 EASTON
High School (1)
Elementary School (1)
Junior College (1)
Fire Station
Bowles Electric Sub-Station
Atchison Topeka & Santa Fe Railroad
43 MALAGA
Elementary Schools (2)
Water Treatment Plant
Atchison Topeka & Santa Fe Railroad

44 FOWLER
High School (1)
Elementary School (1)
Police - Fire Departments
Hospital
U.S. Highway 99
Southern Pacific Railroad
Water Well
Sewer Plant

45 SELMA
U. S. Highway 99
Southern Pacific Railroad
Fire Station
Water Treatment Plant
Sewage Treatment Plant
Elementary School (1)
High School (1)
McCall Electric Sub-Station

46 KINGSBURG
U. S. Highway 99
Southern Pacific Railroad
City Hall
Fire and Police Facilities
Telephone Relay
District Hospital
High School (1)
Elementary Schools (3)
Water Treatment Facilities

47 LATON
High School (1)
Elementary School (1)
Hardwick Electric Sub-Station
Atchison Topeka & Santa Fe Railroad

48 CONEJO
Elementary School (1)
Atchison Topeka & Santa Fe Railroad

49 MONMOUTH
Elementary School (1)
Atchison Topeka & Santa Fe Railroad

50 REEDLEY
Police Department
City Hall
County Building
Fire Department
National Guard Armory
Reedley College
Elementary Schools (5)
High Schools (2)
Sierra King Hospital
Reedley Community Center
Atchison Topeka & Santa Fe Railroad
Reedley Electric Sub-Station
Southern Pacific Railroad

51 PARLIER
Southern Pacific Railroad
Atchison Topeka & Santa Fe Railroad
Elementary Schools (2)
High School (1)
Parlier Electric Sub-Station

52 DEL REY
Elementary School (1)
Sheriff Station
Atchison Topeka & Santa Fe Railroad

53 SANGER
High School (1)
Elementary (5)
Fire Station
Sanger Electric Sub-Station
Southern Pacific Railroad

54 FRESNO
Malaga Electric Sub-Station
Fresno Electric Sub-Station
California Avenue Electric Sub-Station
Barton Electric Sub-Station
Ashlan Avenue Electric Sub-Station
Manchester Electric Sub-Station
Bullard Electric Sub-Station
City of Fresno Water System
City of Fresno Sanitary System
Day Care Centers (35)
Convalescent Hospitals (23)
Fresno Unified School District
Elementary Schools (57)
Junior High (14)
High School (8)
San Joaquin Memorial High School
Fresno Community Hospital
Sierra Hospital
St. Agnes Hospital
Valley Children's Hospital
Valley Medical Center
Veteran's Hospital
St. Agnes (site)
Various radio & T.V. stations
Navy Center
National Guard Armory
Fresno Civic Center
Fresno County Medical Campus

CITY OF FRESNO
Fire Department Headquarters
Parks and Recreation Department
Fresno Transit
City-County Housing Authority
Fresno Redevelopment Agency

FRESNO COUNTY
Agricultural Commissioner
Farm and Home Advisor
Juvenile Probation Complex
Welfare Building

STATE OF CALIFORNIA
California Highway Patrol
Department of Fish and Game
Department of Motor Vehicles
Department of Transportation
Department of Water Resources
Human Resources Development Service Center

U. S. GOVERNMENT
Fresno Air Terminal Office Space
Department of Agriculture
Internal Revenue Service Regional Center
U. S. Postal Service Main Office
Eight Branch Post Offices

CITY OF FRESNO
City Hall
Convention Center
Police Department Building
Memorial Auditorium & City Offices

COUNTY OF FRESNO
Courthouse and Administration Bldg.
Hall of Records
Law Enforcement Building
Elections Building
County Schools Administration Building

FRESNO COUNTY MEDICAL CAMPUS
Public Health Department Building
Mental Health Department Building
Welfare Department Building
Planning & Public Works Building
Valley Medical Center

COLLEGES AND UNIVERSITIES
California Christian College
Mennonite Brethren Biblical Seminary
Pacific College
West Coast Bible College
California State University, Fresno
Fresno City College

55 CLOVIS
Police Station
Fire Department
Government Offices
Unified Elementary Schools (8)
High School (1)
Intermediate Schools (1)
Clovis Electric Sub-Station
Southern Pacific Railroad
Clovis Memorial Hospital

56 AUBERRY
Elementary School (1)
Sierra High School
Auberry Electric Sub-Station

57 TOLLHOUSE
Elementary School (1)

58 NAVELCENCIA
Elementary School (1)
Atchison Topeka & Santa Fe Railroad

59 ORANGE COVE
Elementary School (3)
Atchison Topeka & Santa Fe Railroad

60 MIRAMONTE
Elementary School (1)

61 BALCH CAMP
Elementary School (1)

62 CENTERVILLE
Elementary School (1)
Atchison Topeka & Santa Fe Railroad

63 Coalinga Sub-Station No. 2
64 Asbestos Sub-Station
65 Califax Electric Sub-Station
66 Cantua Electric Sub-Station
67 Westlands Electric Sub-Station
68 Panoche Electric Sub-Station
69 Kearney Electric Sub-Station

70 SILVER CREEK
Hammonds Electric Sub-Station

71 ORO LOMA
Oro Loma Electric Sub-Station

72 Line Creek Electric Sub-Station

73 PINEDALE
Water Treatment Plant
Sewage Treatment Plant
Southern Pacific Railroad

KINGS COUNTY

Index of Critical Facilities

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3	T 20S, R 20E: Empire Weir No. 2
4	T 17S, R 21E: Last Chance Weir Lemoore Divide Weir
5	T 17S, R 22E: Peoples Weir
6	Armona
7	Avenal
8	Corcoran
9	El Rancho and Hamblin
10	Grangeville
11	Hanford
12	Home Garden
13	Kettleman City
14	Lemoore
15	Naval Air Station - Lemoore
16	Stratford
17	Hardwick
18	Burris Park
19	Guernsey
20	T 24S, R 19E: Two Elec. Sub-Stations
21	Tulare Lake
22	Angiola
23	Kettleman Hills

KINGS COUNTY

List of Critical Facilities

Location Index	Community/Facility
1	Crescent Weir & Elec. Sub-Stations (2)
2	Empire Weir No. 1
3	Empire Weir No. 2
4	Last Chance Weir Lemoore Divide Weir
5	Peoples Weir
6	ARMONA Armona Fire Station Armona Union Academy Armona Union Elementary School Armona Public Utilities District (Water) Armona Sanitary District Seventh Day Adventist Elementary & High School
7	AVENAL Avenal Community Service District (Water & Sewer) Schools (2) Avenal Fire Station Avenal Sheriff Sub-Station Veterans Memorial Hall Avenal District Hospital Airport Sewer Farm
8	CORCORAN Atchison Topeka & Santa Fe Railroad City of Corcoran (Water & Sewage) Schools (5) Police Department Fire Station Corcoran District Hospital

8 CORCORAN (cont.)
Veterans Hall
Continental Telephone Company
Pacific Gas & Elec. Sub-Station
Justice Court
Mental Health Service
Sheriff's Sub-Station
Corcoran Airport
Corcoran Community Service Center
Electrical Sub-Station

9 EL RANCHO & HAMBLIN
Curtis Water Company
Hamblin Mutual Water Company
Public Building (1)
Southern Pacific Railroad

10 GRANGEVILLE
School
Fire Department

11 HANFORD
City Offices
Airport
Fire Department
Police Department
Sewage Plant
Hanford Christian School
Hanford Community Hospital
Schools (10)
Atchison Topeka & Santa Fe Railroad
Southern Pacific Railroad
Radio Station - KLAN
Radio Station - KNGS
Radio Station - KOAD
Pacific Telephone
California Highway Patrol Office
Sheriff's Office
Electrical Sub-Stations (2)

12 HOME GARDEN
Home Garden Community Services District (Water)
School
Atchison Topeka & Santa Fe Railroad
Electrical Sub-Station

13 KETTLEMAN CITY
Interstate 5
Schools (3)
Kettleman City Water System
California Aqueduct
Kettleman Fire Station
Sheriff Sub-Station

14 LEMOORE
City of Lemoore (Water & Sewage)
City Hall (Police)
Schools (6)
Private Schools (2)
Southern Pacific Railroad
Fire Department
Lemoore Justice Court

15 NAVAL AIR STATION - LEMOORE
U. S. Navy (Water & Sewer)
Airstrip
Atchison Topeka & Santa Fe Railroad
West Hills College
Chapman College Residence Center
Akers Elementary School
Neutra Elementary School
Hospital
Fire Department
Security Department
Electrical Sub-Station

16 STRATFORD
Stratford Public Utility District (Water & Sewer)
Schools (2)
County Fire Department
Pacific Telephone Company
Southern Pacific Railroad

17 HARDWICK
Hardwick Mutual Water Company
Fire Station

18 BURRIS PARK
Fire Department
Electrical Sub-Station

19 GUERNSEY
Fire Department

20 Las Perillas Electrical Sub-Station
Badger Hill Electrical Sub-Station

21 TULARE LAKE
Electrical Sub-Station

22 ANGIOLA
Electrical Sub-Station

23 KETTLEMAN HILLS
Electrical Sub-Station

MADERA COUNTY

Index of Critical Facilities

Location Index	Area/Facility
1	T 09S, R 16E: Berenda Slough
2	T 09S, R 20E: Black Hawk, Spring
3	T 07S, R 22E: Crane Valley
4	T 09S, R 22E: Kerckhoff Dam
5	T 10S, R 20E: Lake Jane
6	T 10S, R 18E: Madera Lake
7	T 03S, R 24E: McLure Lake
8	T 09S, R 23E: Redinger Dam
9	T 08S, R 22E: No. 2 Reservoir
	T 08S, R 22E: No. 2 Forebay
10	T 04S, R 24E: Rutherford Lake
11	T 09S, R 15E: Sierra Vista
12	Madera
13	Chowchilla
14	Dairyland
15	Alview
16	Berenda
17	La Vina
18	El Peco
19	Ripperdan
20	Trigo
21	Bonita
22	Oakhurst
23	Coarsegold
24	Bass Lake
25	North Fork
26	Ahwahnee
27	Raymond
28	Fairmead
29	Borden (S.S.)
30	Yosemite Forks
31	O'Neals
32	Hidden Lake
33	Buchanan Lake

MADERA COUNTY

List of Critical Facilities

Location Index	Community/Facility
1	Berenda Slough Dam
2	Black Hawk Dam
	Spring Dam
3	Crane Valley Dam
4	Kerckhoff Diversion Dam
5	Lake Jane Dam
6	Madera Lake Dam
7	McLure Lake Dam
8	No. 1 Forebay
9	No. 2 Reservoir
	No. 2 Forebay
10	Rutherford Lake Dam
11	Sierra Vista Dam
12	MADERA
	John Adams School
	Westgate Manor Convalescent Hospital
	Thomas Jefferson Jr. High School
	Madera County Fairgrounds
	Madera Raceway
	Madera Fire Station No. 1
	James Madison School
	High School Stadium
	Madera Union High School
	Parkwood Sewage Treatment Plant
	St. Joachim School
	Madera City Hall
	Madera County Government Center
	Madera County Jail
	Madera County Sheriff's Office
	Madera City Police Department
	George Washington School
	Madera Fire Station No. 2
	James Monroe School
	National Guard Armory
	Sierra Vista School
	Madera Airport
	Madera Convalescent Hospital
	Madera Community Hospital
	Millview School
	Community Center
	KHOT Radio
	Pacific Telephone
	Electrical Sub-Station
	U. S. Highway 99
	Southern Pacific Railroad
	Madera Sewer System
	Madera Water Works
	County-Health Dept.
	Juvenile Hall
	California Highway Patrol Office
13	CHOWCHILLA
	Memorial Hospital
	Fuller Elementary School
	Division of Forestry Fire Station
	Stephens Elementary School
	Wilson Elementary School
	Justice Court
	Union High School
	City Hall (Fire & Police)
	Madera County Fairgrounds
	Sewer System & Water Works
	Airport
	U. S. Highway 99
	Southern Pacific Railroad
	Electrical Sub-Station
	Convalescent Hospital
14	DAIRYLAND
	School
	Fire Station
	Electrical Sub-Station
15	ALVIEW
	School
16	BERENDA
	Southern Pacific Railroad
	U. S. Highway 99
	Fire Station
	Microwave Tower
17	LA VINA
	School
18	EL PECO
	Electrical Sub-Station
19	RIPPERDAN
	School
	Fire Station
20	TRIGO
	Atchison Topeka & Santa Fe Railroad
21	BONITA
	Electrical Sub-Station
22	OAKHURST
	School
	Fire Station
	Courthouse
	Sewage Treatment Plant
	Community Center
23	COARSEGOLD
	School
	Fire Station
	Community Center
24	BASS LAKE
	School
	Marina View Heights Treatment Plant
	Lake Shore Park Treatment Plant
25	NORTH FORK
	School
	Ponderosa Telephone Company
	Fire Department
	North Fork Sewage Treatment Plant
26	AHWAHNEE
	School
	Goldside Estates Treatment Plant
27	RAYMOND
	School
	Fire Station
	Sierra Telephone Company
28	FAIRMEAD
	School
29	BORDEN
	Electrical Sub-Station
	U. S. Highway 99
	Southern Pacific Railroad
30	YOSEMITE FORKS
	Fire Station (2)
31	O'NEALS
	Fire Department
	Spring Valley School
	Ponderosa Telephone Co.
32	Hidden Lake
33	Buchanan Lake

MARIPOSA COUNTY

Index of Critical Facilities

Location Index	Area/Facility
1	Mariposa
2	Catheys Valley
3	Oak Grove
4	Water Treatment Plant (Mariposa)
5	Greeley Hill
6	Coulterville
7	Mormon Bar
8	Hornitos
9	Airport (Mariposa)
10	Darrah
11	El Portal
12	Wawona
13	Boot Jack Road
14	Wawona Tunnel
15	Big Oak Flat Road Tunnels
16	Yosemite Village
17	T 02S, R 16E: Green Valley Dam
18	T 07S, R 19E: Hendricks Dam
19	T 04S, R 19E: Mariposa Pines Dam
20	T 03S, R 16E: McMahon Dam
21	T 05S, R 15E: McSwain Dam
22	T 02S, R 17E: Metzger Dam
23	T 04S, R 15E: New Exchequer Dam
24	T 05S, R 18E: Stockton Creek Dam
25	T 06S, R 16E: Bear Dam
26	T 07S, R 17E: Mariposa Dam
27	T 07S, R 16E: Owens Creek Dam
28	Bear Valley
29	Briceburg
30	Indian Flat

MARIPOSA COUNTY

List of Critical Facilities

Location Index	Community/Facility
1	MARIPOSA
	Fremont Hospital
	Fire House
	Sheriff's Office
	Court House
	Hall of Records
	Health Department
	California Highway Patrol
	Elementary School
	High School
	Sewer Treatment
	Water Treatment
	Fairgrounds
2	CATHEYS VALLEY
	Community Hall
	School
3	OAK GROVE
	Community Club
4	McCLURE LAKE
	Water Treatment Plant
5	GREELEY HILL
	Community Club
	Library
	Elementary School
6	COULTERVILLE
	Fire Station (2)
	Community Club
	Justice Court
	Odd Fellow's Hall
7	MORMON BAR
	Fire Station
8	HORNITOS
	Elementary School
	Fire Station
9	HIGHWAY 49 - MOUNT BULLION
	Airport
	California Hwy. Patrol Repeater Station
10	DARRAH
	Community Hall
11	EL PORTAL
	Sewage Treatment Plant
	Fire Station
	Elementary School
12	WAWONA
	School
13	BOOT JACK
	School
14	STATE HIGHWAY 41
	Wawona Tunnel
15	BIG OAK FLAT ROAD
	Tunnels (3)
16	YOSEMITE VILLAGE
	Hospital
17	Green Valley Dam
18	Hendricks Dam
19	Mariposa Pines Dam
20	McMahon Dam
21	McSwain Dam
22	Metzger Dam
23	New Exchequer Dam
24	Stockton Creek Dam
25	Bear Dam
26	Mariposa Dam
27	Owens Creek Dam
28	BEAR VALLEY
	Electrical Sub-Station
29	BRICEBURG
	Electrical Sub-Station
30	INDIAN FLAT
	Electrical Sub-Station

TULARE COUNTY

Index of Critical Facilities

Location Index	Area/Facility
1	T 17S, R 31E: Three Dams
2	T 20S, R 24E: Elk Bayou Dam
3	T 22S, R 29E: Larson Dam
4	T 21S, R 28E: Success Dam
5	T 17S, R 27E: Terminus Dam
6	Tule Indian Reservation
7	Visalia
8	Tulare
9	Porterville
10	Woodlake
11	Exeter
12	Dinuba
13	Farmersville
14	Lindsay

15 Cutler-Orosi
16 Goshen
17 Ivanhoe
18 Lemon Cove
19 Strathmore
20 Alpaugh
21 Earlimart
22 Pixley
23 Tipton
24 Woodville
25 Richgrove
26 Terra Bella
27 Springville
28 Three Rivers
29 Traver
30 London
31 Delft Colony
32 Sultana
33 Monson
34 Yettem
35 Seville
36 Elderwood
37 Waukena
38 Allensworth
39 Ducor
40 Poplar
41 Blue Ridge
42 Oceola
43 T 24S, R 26E: Two Elec. Sub-Stations
44 Wheatland
45 Bliss
46 Liberty
47 Chatham
48 T 17S, R 26E: Three Elec. Sub-Stations
49 Olancha

TULARE COUNTY

List of Critical Facilities

Location Index	Community/Facility
1	Crystal Lake
	Lady Franklin Lake
	Upper Monarch Lake
2	Elk Bayou
3	Larson
4	Success & Electrical Sub-Station
5	Terminus
6	TULE INDIAN RESERVATION
	Tribal Community Center
	Reservation Health Clinic
	Reservation Child Care Center
7	VISALIA
	Mineral King Union School
	Municipal Court Mall
	Senior Citizens Center
	Juvenile Hall
	Crowley School
	North Visalia Community Center
	Fairview School
	Green Acres Airport
	Green Acres School
	Sequoia High School
	Highland School
	City Hall - Police
	Chamber of Commerce
	Kaweah District Hospital
7	VISALIA (cont.)
	Visalia Community Center
	Redwood High School
	County Civic Center
	Willow Glen School
	California Highway Patrol Office
	Armory
	College of the Sequoias
	Veva Blunt School
	Royal Oaks School
	Fire Stations (City & County/State Main Facility)
	Divisadero School
	Visalia Community Hospital
	Conyer School
	Mount Whitney High School
	Washington School
	Mountain View School
	Crestwood School
	Linwood School
	City of Visalia Water Conservation Plant
	Radio Station - KONG
	Television Station - KMPH
	Pacific Telephone
	State Highway 198
	Southern Pacific Railroad
	Atchison Topeka & Santa Fe Railroad
	Visalia Mets Baseball Field
	Two Electrical Sub-Stations
8	TULARE
	Tulare Western High School
	Maple School (includes school for mentally retarded)
	Roosevelt School
	Mulcahy School
	Tulare County Hospital
	City Hall - Police Department
	Veterans Memorial Bldg.
	Tulare Union High School
	Tulare Union High School Farm
	Wilson School
	Cherry Avenue School
	St. Aloysius School
	Garden Avenue School
	Tulare Air Park
	Tulare District Hospital
	Radio Station - KBOS
	Radio Station - KCOK
	Radio Station - KCEN
	State Highway 99
	Atchison Topeka & Santa Fe Railroad
	Southern Pacific Railroad
	Tulare View Hospital
	Sewage Treatment Plant
	Water Distribution Facilities
	Tulare Fire Department (2 stations)
	Tulare Community Center
	Tulare County Fairgrounds
	Two Electrical Sub-Stations
	Major natural gas distribution trunk line parallels So. Pacific R.R.

9 PORTERVILLE
Elementary School (7)
Private Schools (2)
Hospital
High School (2)
Porterville College
Junior High School (2)
Porterville State Hospital
Municipal Airport & State/Federal Forestry Staging Area
Auditorium
Fire Station (4)
Armory
Civic Center - Police - Courthouse & Library
Communication Center & Water Monitoring Board
Atchison Topeka & Santa Fe Railroad
Southern Pacific Railroad
State Highway 65
State Highway 190
Radio Station - KTIP
Radio Station - K100
Eagles Lodge
California Highway Patrol Office
Electrical Sub-Station
Paul Bunyan Lodge
VFW Hall
Elks Lodge
American Legion Hall
Water Conservation Plant (plus facilities at the Hospital)

10 WOODLAKE
Elementary Schools (2)
Recreation Building
High School
Memorial Building
Fire Station
City Hall - Police
Woodlake Airport
Sewage Treatment Plant
Water Storage Facilities
Atchison Topeka & Santa Fe Railroad

11 EXETER
Exeter City Hall - Police Department - Fire Department
Wilson School
Lincoln School
Exeter High School
Memorial Hospital
Memorial Building
Justice Court
Water Tanks
Sewage Treatment
Southern Pacific Railroad
Atchison Topeka & Santa Fe Railroad
Exeter Medical Clinic
Continental Telephone Company
Electrical Sub-Station

12 DINUBA
Alta Hospital
Lincoln Elementary School
Washington Junior High School
Fire Department
Dinuba High School
Dinuba Junior Academy
Memorial Building
City Hall - Water Department
Red Cross Building
County Building and Courthouse
Jefferson Elementary School
Wilson Elementary School
Dinuba Convalescent Hospital
Police Department
Sewage Treatment Plant
Southern Pacific Railroad
Pacific Telephone
Electrical Sub-Station
Dinuba Recreation Building
Water Tank

13 FARMERSVILLE
City Hall - Police Department
J. E. Hester Elementary School
G. L. Snowden School
Farmersville Fire Station
Justice Court
Sewage Treatment Plant
Electric Sub-Station

14 LINDSAY
High School
Lindsay District Hospital
Veterans Memorial Building
City Hall (Police & Fire)
Jefferson Elementary School
Washington Elementary School
Electrical Sub-Station
Junior High School
Water Tank Supply
Atchison Topeka & Santa Fe Railroad
Exeter-Lindsay Airport
General Telephone Company
Tulare County Fire Department

15 CUTLER-OROSI
Cutler School
El Monte School
Lovell High School
Orosi High School
Palm School
Cutler-Orosi Fire Station
Health Department
Sheriff Sub-Station
Atchison Topeka & Santa Fe Railroad
Alta Airport
Electrical Sub-Station

16 GOSHEN
Goshen Community Service District
Goshen Community Center
Elementary School
State Highway 99
Southern Pacific Railroad
Electrical Sub-Station

17 IVANHOE
Ivanhoe Memorial Hall
1 School
Southern Pacific Railroad
Piepgrass Airport
Electrical Sub-Station

18 LEMON COVE
Fire Station
1 School
Electrical Sub-Station

19 STRATHMORE
Sewage Treatment Plant
Strathmore Elementary School
Strathmore Fire Station
Strathmore Union High School
Atchison Topeka & Santa Fe Railroad
Electrical Sub-Station

20 ALPAUGH
1 School
Alpaugh Fire Station
Atchison Topeka & Santa Fe Railroad
Electrical Sub-Station

21 EARLIMART
2 Schools
Water System
Sewage System
Fire Department
State Highway 99
Southern Pacific Railroad
Earlimart Mental Health Clinic
Electrical Sub-Station

22 PIXLEY
Water System
Sewage System
1 School
Fire Department
Sheriff Sub-Station
Pixley Airport
State Highway 99
Southern Pacific Railroad
Electrical Sub-Station

23 TIPTON
Water System
Sewage System
School
Fire Department
Tipton Memorial Hall
State Highway 99
Southern Pacific Railroad
Electrical Sub-Station

24 WOODVILLE
1 School
Water System
Sewer System
Fire Station
Woodville Memorial Building
Electrical Sub-Station

25 RICHGROVE
Water System
Elementary School
Burum Airport
Southern Pacific Railroad
Electrical Sub-Station

26 TERRA BELLA
Fire Station
Sewage System
School
Southern Pacific Railroad
Electrical Sub-Station

27 SPRINGVILLE
School
Mountain Home Conservation Camp
Milo Fire Station
Springville Fire Station
Camp Nelson Fire Station
Springville Hospital
Electrical Sub-Station

28 THREE RIVERS
School
Three Rivers Fire Station
Hammond Fire Station
Three Rivers Memorial Building
Three Rivers Airport
Community Center

29 TRAVER
State Highway 99
Southern Pacific Railroad (includes microwave relay)
Water System
School

30 LONDON
Sewer System
Fire Station
Water System

31 DELFT COLONY
School

32 SULTANA
School

33 MONSON
School

34 YETTEM
School
Water System
Sewage System
Sequoia Field

35 SEVILLE
Atchison Topeka & Santa Fe Railroad
Water System
School

36 ELDERWOOD
School
Rodeo Grounds

37 WAUKENA
School
Fire Station
Atchison Topeka & Santa Fe Railroad

38 ALLENSWORTH
Water System
School
Atchison Topeka & Santa Fe Railroad

39 DUCOR
School
Fire Station
Southern Pacific Railroad
Water System

40 POPLAR
School
Poplar Memorial Building
Poplar Fire Station
Electrical Sub-Station

41 BLUE RIDGE
Microwave Station

42 OCEOLA
Electric Sub-Station

43 Columbine Electrical Sub-Station
Mariposa Electrical Sub-Station

44 WHEATLAND
Electrical Sub-Station

45 BLISS
Electrical Sub-Station
46 LIBERTY
Electrical Sub-Station
47 CHATHAM
Electrical Sub-Station
48 Venice Hill Electrical Sub-Station
Stone Corral Electrical Sub-Station
Three Rivers Electrical Sub-Station
49 OLANCHA
Electrical Sub-Station

APPENDIX E

SEISMIC SAFETY ELEMENT GUIDELINES

SEISMIC SAFETY ELEMENT

AUTHORITY

A. Authority

Government Code Section 65302(f) requires a seismic safety element of all city and county general plans, as follows:

> A seismic safety element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves such as tsunamis and seiches.
>
> The seismic safety element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves.

The effect this section is to require cities and counties to take seismic hazards into account in their planning programs. All seismic hazards need to be considered, even though only ground and water effects are given as specific examples. The basic objective is to reduce loss of life, injuries, damage to property, and economic and social dislocations resulting from future earthquakes.

B. Background

Earthquake losses in California through the remainder of this century, assuming that additional significant counter-measures are not taken, have recently been estimated at approximately $20 billion (Urban Geology Master Plan, California Division of Mines and Geology) Estimates of potential loss of life for this period range well up into the thousands and most of this loss is preventable.

The most widespread effect of an earthquake is <u>ground shaking</u>. This is also usually (but not always) the greatest cause of damage. Structures of all types, including engineered structures and public utility facilities, if inadequately constructed or designed to withstand the shaking force, may suffer severe damage or collapse. The vast majority of deaths during earthquakes are the result of structural failure due to ground shaking. Most such deaths are preventable, even with present knowledge. New construction can and should be designed and built to withstand probable shaking without collapse. The greatest existing hazard in the State is the continued use of tens of thousands of older structures incapable of withstanding earthquake forces. Knowledge of earthquake-resistant design and construction has increased greatly in recent years, though much remains to be learned.

A second effect of earthquakes is ground failure in the form of landslides, rock falls, subsidence and other surface and near-surface ground movements. This is often the result of complete loss of strength of water-saturated sub-surface foundation soils ("liquefaction"), such as occurred near the Juvenile Hall in the 1971 San Fernando earthquake, and in the massive Turnagain Arm landslide in Anchorage, during the 1964 Alaska earthquake. Most such hazardous sites can be either avoided or stabilized if adequate geologic and soil investigations are utilized.

Another damaging effect of earthquakes is ground displacement (surface rupture) along faults. Such displacement of the earth's crust may be vertical, horizontal or both and may offset the ground by as much as 30 feet (as in 1857 in Southern California). It is not economically feasible to design and build foundations of structures (dams, buildings, bridges, etc.) to remain intact across such zones. Fault zones subject to displacement are best avoided in construction. In addition to regional investigations necessary to the basic understanding of faults and their histories, detailed site investigations are needed prior to the approval of construction in any suspected active fault zone. Utilities, roads, canals and other linear structures are particularly vulnerable to damage as the result of ground displacement.

Other damaging effects of earthquakes include tsunamis (seismic sea waves, often called "tidal waves"), such as the one which struck Crescent City and other coastal areas in 1964; and seiches (waves in lakes and reservoirs due to tilting or displacement of the bottom or margin). The failure of dams due to shaking, fault displacement or overtopping (from seiches or massive landsliding into the reservoir) can be particularly disastrous. Most modern dams are designed and constructed to be earthquake-resistant; some older dams were not. In addition to man-made dams, temporary dams may be created by earthquake-triggered landslides. Such inadvertently created dams are certain to fail within a relatively short time.

THE SCOPE AND NATURE OF THE SEISMIC SAFETY ELEMENT

A. A general policy statement that:

1. Recognizes seismic hazards and their possible effect on the community.

2. Identifies general goals for reducing seismic risk.

3. Specifies the level or nature of acceptable risk to life and property (see safety element guidelines for the concept of "acceptable risk").

4. Specifies seismic safety objectives for land use.

5. Specifies objectives for reducing seismic hazard as related to existing and new structures.

B. Identification, delineation and evaluation of natural seismic hazards.

C. Consideration of existing structural hazards.

Generally, existing substandard structures of all kinds (including substandard dams and public utility facilities) pose the greatest hazard to a community.

D. Evaluation of disaster planning program

For near-term earthquakes, the most immediately useful thing that a community can do is to plan and prepare to respond to and recover from an earthquake as quickly and effectively as possible, given the existing condition of the area. The seismic safety element can provide guidance in disaster planning.

E. Determination of specific land use standards related to level of hazard and risk.

METHODOLOGY

As an initial step, it may be helpful to determine what aspects of the element need greater emphasis. If a community is largely developed, emphasis on structural hazards and disaster planning would be most appropriate. This would also be the case for communities whose greatest hazard will be from ground shaking. On the other hand, communities with extensive open areas and areas subject to urbanization may wish to focus on natural seismic hazards and the formulation of land use policies and development regulations to insure that new development is not hazardous.

Additionally, local planning agencies may wish to consider the preparation of the element or portions of the element in joint action. This would be particularly practical for the study of natural seismic hazards.

A. Initial organization

1. Focus on formulating and adopting interim policy based on very general evaluation of earth science information readily available.

2. Evaluate adequacy of existing information in relation to the identified range and severity of problems.

3. Define specific nature and magnitude of work program needed to complete the element in a second stage.

B. Identification of natural seismic hazards

1. General structural geology and geologic history.

2. Location of all active or potentially active faults, with evaluation regarding past displacement and probability of future movement.

3. Evaluation of slope stability, soils subject to liquefaction and differential subsidence.

4. Assessment of potential for the occurrence and severity of damaging ground shaking and amplifying effects of unconsolidated materials.

5. Identification of areas subject to seiches and tsunamis.

6. Maps identifying location of the above characteristics.

C. Identification and evaluation of present land use and circulation patterns should be recognized in the formulation of seismic safety-land use policies.

D. Identification and evaluation of structural hazards relating structural characteristics, type of occupancy and geologic characteristics in order to formulate policies and programs to reduce structural hazard.

E. Formulation of seismic safety policies and recommendations.

F. Formulation of an implementation program.

DEFINITION OF TERMS

A. Acceptable risk: The level of risk below which no specific action by local government is deemed necessary, other than making the risk known.

Unacceptable risk: Level of risk above which specific action by government is deemed necessary to protect life property.

Avoidable risk: Risk not necessary to take because the individual or public goals can be achieved at the same or less total "cost" by other means without taking the risk.

B. Technical Terminology:

Tsunamis: Earthquake-induced ocean waves, commonly referred to as tidal waves.

Seiches:	Earthquake-induced waves in lakes or ponds.
Seismic:	Pertaining to or caused by earthquake.
Soil Liquefaction:	Change of water saturated cohesionless soils to liquid, usually from intense ground shaking; soil loses all strength.
Tectonic, forms, forces, and movements resulting from deformation of the earth's crust:	Movement may be rapid resulting in earthquake or slow (tectonic creep).
Fault:	A plane or surface in earth materials along which failure has occurred and materials on opposite sides have moved relative to one another in response to the accumulation of stress in the rocks.
Active Fault:	A fault that has moved in recent geologic time and which is likely to move again in the relatively near future. (For geologic purposes, there are no precise limits to recency of movement or probable future movement that define an "active fault." Definitions for planning purposes extend on the order of 10,000 years or more back and 100 years or more forward. The exact time limits for planning purposes are usually defined in relation to contemplated uses and structures.)
Inactive Fault:	A fault which shows no evidence of movement in recent geologic time and no evidence of potential movement in the relatively near future.
Seismic Hazards:	Hazards related to seismic or earthquake activity.
Ground Failures:	Include mudslide, landslide, liquefaction, subsidence.
Surface ruptures from faulting:	Breaks in the ground surface resulting from fault movement.

RELATIONSHIPS

A. To Other Elements:

The seismic safety element contributes information on the comparative safety of using lands for various purposes, types of structures and occupancies. It provides primary policy inputs to the land use, housing, open space, circulation and safety elements.

Because of the close relationship with the safety element the local planning agency may wish to prepare these two elements simultaneously or combine the two elements into a single document. If combined, the required content and policies of each element should be clearly identifiable. The local jurisdiction may wish to include the seismic safety element as a part of an environmental resources management element - ERME - as discussed previously.

B. To Environmental Factors:

1. Physical:	Geologic hazards can be a prime determinant of land use capability.
2. Social:	May provide basis of evaluating costs of social disruptions, including the possible loss of life due to earthquake and identifies means of mitigating social impact.
3. Economic:	Cost and benefits of using or not using various areas related to potential damage or cost of overcoming hazard.
4. Environmental Impact Report:	Provides basis for evaluating environmental impact of proposed projects in relation to slope stability, possible structure failure, etc.

C. To Other Agencies:

The State Geologist is required by Chapter 7.5, Divison 2 of the Public Resources Code to delineate by December 31, 1973, special studies zones encompassing certain areas of earthquake hazard on maps and to submit such maps to affected cities, counties, and state agencies for review and comments.

By December 31, 1973, the Division of Mines and Geology will have delineated the special studies zones encompassing all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto faults. The special studies zones will be delineated on U.S. Geological Survey quadrangle sheets. The quadrangles listed in Appendix F will be included in the initial distribution which will begin on or about October 1, 1973, and be completed by December 31, 1973. In addition to the faults named above, all active or potentially active faults within the quadrangles listed will be zoned. The zones are ordinarily about one-quarter mile in width.

The State Mining and Geology Board is required by Chapter 7.5, Division 2 of the Public Resources Code to develop policies and criteria by December 31, 1973, concerning real estate developments or structures to be built within the special studies zones.

IMPLEMENTATION

A. Concurrent or subsequent revision of other general plan elements to give specific recognition to seismic safety policies and criteria.

B. Inclusion of appropriate requirements and procedures in zoning, subdivision and site development regulations and building codes. Designation of special zones with special land development regulations such as "seismic hazards management zones."

C. Preparation of renewal plans for areas where a change in use and development pattern is necessary because of major seismic damage or extreme hazard.

D. Building inspection program to identify unsafe structures and instigate necessary corrective measures.

E. Inclusion of potential earthquake destruction in contingency plans for major disasters and emergencies. Review and liaison with Emergency Preparedness Organizations and Police Departments of overall plans and major public facilities proposals as to their adequacy in emergency situations.

F. Educational programs to develop community awareness of seismic hazards.

G. Updating the building code to reflect changes in technology.

NOTE: These guidelines drew extensively from:

Suggested Interim Guidelines for the Seismic Safety Element in General Plans, prepared by the Governor's Earthquake Council, July, 1972.

Draft Guidelines for the Seismic Safety Element, prepared by Advisory Group on Land Use Planning for Joint Committee on Seismic Safety, California State Legislature, September, 1972.

Seismic Safety Concerns in CIR/OIM Program prepared for CIR by William Spangle & Associates, March, 1972, unpublished.

APPENDIX F

GLOSSARY OF TERMS

(See also Appendix D for definition of terms related to Sec. 65302[f] of the Calif. Gov. Code)

GLOSSARY OF TERMS

ACTIVE FAULT - One that has moved in recent geologic time and which is likely to move again in the relatively near future. Definitions for planning purposes extend on the order of 10,000 years or more back and 100 years or more forward.

ALLUVIAL - Pertaining to or composed of alluvium, or deposited by a stream or running water. (AGI, 1972)

ALLUVIUM - A general term for clay, silt, sand, gravel or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sidement in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope. (AGI, 1972)

AMPLIFICATION - Elaboration; augmentation; addition (Webster). As used herein, near-surface amplification is the augmentation of wave amplitude resulting from the change in physical properties in near-surface layers (See Introduction).

AMPLITUDE - The extent of the swing of a vibrating body on each side of the mean position. (Webster)

BLOCK SLIDE - A translational landslide in which the slide mass remains essentially intact, moving outward and downward as a unit, most often along a pre-existing plane of weakness such as bedding, foliation, joints, faults, etc. (AGI, 1972)

COHESION - Shear strength in a sediment not related to interparticle friction. (AGI, 1972)

COLLUVIUM - (a) A general term applied to any loose heterogenous, and incoherent mass of soil, material or rock fragments deposited chiefly by mass-wasting, usually at the base of a steep slope or cliff. (b) Alluvium deposited by unconcentrated surface runoff or sheet erosion, usually at the base of a slope (AGI, 1972).

COMPACTION - Reduction in bulk volume or thickness of, or the pore space within, a body of fine-grained sediments in response to the increasing weight of overlying material that is continually being deposited, or to the pressure resulting from earth movements within the crust. It is expressed as a decrease in porosity brought about by a tighter packing of the sediment particles (AGI, 1972).

CONSOLIDATED MATERIAL - Soil or rocks that have become firm as a result of compaction.

DAMPING - The resistance to vibration that causes a delay of motion with time or distance, e.g. the diminishing amplitude of an oscillation (AGI, 1972).

DIFFERENTIAL SETTLEMENT - Nonuniform settlement; the uneven lowering of different parts of an engineering structure, often resulting in damage to the structure (AGI, 1972).

DIP SLIP FAULT - A fracture along which the apparent movement has been predominantly parallel to the dip (from Gilluly, et al)

DISPLACEMENT (Geological) - The relative movement of the two sides of a fault, measured in any chosen direction; also, the specific amount of such movement. Displacement in an apparently lateral direction includes strike-slip and strike separation; displacement in an apparently vertical direction includes dip-slip and dip separation (AGI, 1972).

DISPLACEMENT (Engineering) - The geometrical relation between the position of a moving object at any time and its original position. (Webster)

EPICENTER - That point on the earth's surface which is directly above the focus of an earthquake (AGI, 1972).

FAULT - A surface or zone of rock fracture along which there has been displacement, from a few centimeters to a few kilometers in scale (AGI, 1972).

FAULT SURFACE - In a fault, the surface along which displacement has occurred (AGI, 1972).

FAULT SYSTEM - Two or more interconnecting fault sets (AGI, 1972).

FAULT ZONE - A fault zone is expressed as a zone of numerous small fractures or of breccia or fault gouge. A fault zone may be as wide as hundreds of meters (AGI, 1972).

FOCUS (Seism) - That point within the earth which is the center of an earthquake and the origin of its elastic waves. Syn: hypocenter; seismic focus; centrum (See Introduction) (AGI, 1972).

FOOT WALL - (see hanging wall)

GROUND RESPONSE - A general term referring to the response of earth materials to the passage of earthquake vibration. It may be expressed in general terms (maximum acceleration, dominant period, etc), or as a ground-motion spectrum.

HANGING WALL - With an inclined fault plan or surface, the side projecting below is called the foot wall, while the overhanging side is called the hanging wall (from Grabau)

HYPOCENTER - See focus.

INTENSITY (earthquake) - A measure of the effects of an earthquake at a particular place on humans and/or structures. The intensity at a point depends not only upon the strength of the earthquake, or the earthquake magnitude, but also upon the distance from the point to the epicenter and the local geology at the point (AGI, 1972).

ISOSEISMAL LINE - A line connecting points on the earth's surface at which earthquake intensity is the same. It is usually a closed curve around the epicenter. Syn: isoseism, isoseismic line; isoseismal (AGI, 1972).

LIQUEFACTION - A sudden large decrease in the shearing resistance of a cohesionless soil, caused by a collapse of the structure by shock or strain, and associated with a sudden but temporary increase of the pore fluid pressure (AGI, 1972).

MACROSEISMIC DATA - Used herein to describe instrumentally recorded earthquakes generally in the range of Richter magnitude 3.0 or more. (This use differs from the AGI definition of "macroseismic observations").

MAGNITUDE (earthquake) - A measure of the strength of an earthquake or the strain energy released by it, as determined by seismographic observations. As defined by Richter, it is the logarithm, to the base 10, of the amplitude in microns of the largest trace deflection that would be observed on a standard torsion seismograph (static magnification = 2800; period = 0.8 sec; damping constant = 0.8) at a distance of 100 kilometers from the epicenter (AGI, 1972).

MICROSEISMIC DATA - Used herein to describe instrumentally recorded earthquakes generally in the range of Richter magnitude 3.0 or less. (This use is consistent with the AGI definition of microseism and microseismometer, but is more restricted than their definition of microseismic data).

NATURAL PERIOD - The period at which maximum response of a system occurs. The inverse of resonant frequency.

NORMAL FAULT - A fault in which the hanging wall appears to have moved downward relative to the footwall. The angle of the fault is usually 45-90 degrees. There is dip-separation, but there may or may not be dip-slip (AGI, 1972).

PREDOMINANT PERIOD - The period of the acceleration, velocity or displacement which predominates in a complex vibratory motion. In the analysis of earthquake vibrations, predominant period is normally the period of the maximum amplitude of the acceleration spectrum.

RESPONSE SPECTRUM - An array of the response characteristics of a structure or structures ordered according to period or frequency. The structures are normally single-degree-of-freedom oscillators, and the characteristics may be displacement, velocity or acceleration (see Introduction).

SEICHE - All standing waves on any body of water whose period is determined by resonant characteristics of the containing basin as controlled by its physical dimensions (U.S. Geol. Survey Prof. Paper 544-E)

SEISMIC SEICHE - Standing waves set up on rivers, reservoirs, ponds and lakes at the time of passage of seismic waves from an earthquake (U.S.Geol. Survey Prof. Paper 544-E)

SHEAR - A strain resulting from stresses that cause or tend to cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact; specifically, the ratio of the relative displacement of these parts to the distance between them (AGI, 1972).

SHEAR WAVE OR S-WAVE - That type of seismic body wave which is propagated by a shearing motion of material so that there is oscillation perpendicular to the direction of propagation. It does not travel through liquids (AGI, 1972).

SLIP - On a fault, the actual relative displacement along the fault plane of two formerly adjacent points on either side of the fault. Slip is three dimensional, whereas separation is two dimensional (AGI, 1972).

STRIKE-SLIP FAULT - A fault, the actual movement of which is parallel to the strike (trend) of the fault (AGI, 1972).

SUBSIDENCE - A local mass movement that involves principally the gradual downward settling or sinking of the solid earth's surface with little or no horizontal motion and that does not occur along a free surface (not the result of a landslide or failure of a slope (AGI, 1972).

TECTONIC - Of or pertaining to the forces involved in, or the resulting structures or features of the upper part of the earth's crust. (mod. from AGI, 1972)

TSUNAMI - A gravitational sea wave produced by any large-scale, short-duration disturbance of the ocean floor, principally by a shallow submarine earthquake, but also by submarine earth movement, subsidence, or volcanic eruption, characterized by great speed of propagation (up to 950 km/hr.), long wavelength (up to 200 km.), long period (5 min. to a few hours, generally 10-60 min.), and low observable amplitude on the open sea, although it may pile up to great heights (30 m. or more) and cause considerable damage on entering shallow water along an exposed coast, often thousands of kilometers from the source (AGI, 1972).

UNCONSOLIDATED MATERIAL - A sediment that is loosely arranged or unstratified or whose particles are not cemented together, occurring either at the surface or at depth (AGI, 1972).

WATER TABLE - The surface between the zone of saturation and the zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere (AGI, 1972).

APPENDIX G

ABBREVIATED BIBLIOGRAPHY

ABBREVIATED BIBLIOGRAPHY

The following documents were utilized in preparing the Summary and Policy Report in addition to the technical support documents listed in the bibliography of the Technical Report - Part I

American Society of Civil Engineering Magazine - The Balanced Risk Concept -- New Approach to Earthquake Building Codes, No. 13.56, 1970

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TECHNICAL REPORT
for the
FIVE COUNTY SEISMIC SAFETY ELEMENT
for the
GENERAL PLANS
of
FRESNO, KINGS, MADERA, MARIPOSA
and
TULARE COUNTIES
and
THEIR RESPECTIVE INCORPORATED CITIES

APRIL, 1974

CONSULTANT
ENVICOM CORPORATION
SHERMAN OAKS, CALIFORNIA

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CREDITS

POLICY ADVISORY COMMITTEE

Hon. Robert E. Harrell, Chairman, Representing Tulare County Association of Governments
Evon G. Cody, Co-Chairman

Council of Fresno County Governments - Representatives

John Donaldson, Supervisor - Fresno County Board of Supervisors
Paul Wasemiller, Councilman - City of Fresno
Johnnie Larson, Councilman - City of Coalinga

Kings County Regional Planning Agency - Representatives

Evon G. Cody, Supervisor - Kings County Board of Supervisors
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Harold Balmat - Board of Supervisors
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Glen Jessing - Special District Representative

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William H. Moffitt - Mariposa County Board of Supervisors
Frank L. Long, Jr. - Mariposa County Board of Supervisors
Peter J. Artero - Special District Representative

Tulare County Association of Governments - Representatives

Robert E. Harrell - Tulare County Board of Supervisors and Chairman of the Tulare County Association of Governments
Norman Griesiach - City of Tulare and Vice Chairman of Tulare County Association of Governments
Frank Lagomarsino - Special District Representative, Board of Governors, Tulare County Association of Governments

TECHNICAL ADVISORY COMMITTEE

King Patrick Leonard, AIP, Project Manager and Chairman of Technical Advisory Committee
Dennis Triplitt, Co-Chairman

Council of Fresno County Governments - Representatives

Peter Oswald, Executive Director
David D. Knight, Planning Director

Kings County Regional Planning Agency - Representatives

Charles Gardner, Executive Secretary
Dennis Triplitt, Assistant Director, Kings County Planning Department

Madera County

Leonard Garoupa, Planning Director, County of Madera
Al Muller, City Planner, City of Madera

Mariposa County

Peter J. Artero, County Engineer
William C. Lincoln, Deputy County Engineer

Tulare County Association of Governments

Robert L. Wall, Executive Secretary
King Patrick Leonard, AIP, Division Head, Areawide Planning

Consultants

ENVICOM CORPORATION

Joseph G. Johns, President
Donald O. Asquith, PhD, Vice President
Charles A. Swift, Geologist
Pamela Tormey, Secretarial

QUINTON/REDCATE (sub contractor)

Elwood C. Teacher, Planning Director
Carl Scheirmeyer, Planner
Michael S. Metcalfe, Planner
Darold A. Nelson, ASCE, Chief Structural Engineer

REPORT PRODUCTION AND GRAPHICS - Tulare County Planning Department

Graphics

Terrill Ohlwein - Graphics Illustrator
Daniel W. Paulson - Draftsman III
Jose B. Aguilar - Draftsman II
Marine M. Miller - Draftsman II

Clerical

Esther S. Walker - Administrative Secretary
Janice M. Maxwell - Senior Clerk Typist
Elizabeth A. Meyers - Intermediate Clerk Typist

REPRODUCTION - Central Duplicating, Tulare County

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The following people gave the Policy Committee, Technical Committee and Consultants assistance in the preparation of this report:

Bruce Blackerby - Geology Department, Calif. State University at Fresno

Phil Brumit - Director of Emergency Services, Tulare County

Bill R. Briner - District Conservationist, USDA Soil Conservation Service - Tulare County

John Buada - Planner, Fresno County Planning Department

John L. Burnett - Geologist, California Div. of Mines and Geology

Tim Cockrum - Geologist, Fresno County Public Works Department

Peter Diaz - Administrator, California Council on Intergovermmental Relations

Ernest G. Eaton - District Conservationist, USDA Soil Conservation Service, Kings County

George Finney - Planner III, Tulare County Planning Department

Thomas E. Gay, Jr. - Geologist, California Division of Mines and Geology

Ray Gonzales - City Planner, City of Clovis

Richard Gresham - Planner, City of Fresno, Planning Department

Gary Irish - Planning Director, City of Porterville

Erik Kaarlela - City of Coalinga/California State Division of Oil & Gas

Donald L. Lucas - District Conservationist, USDA Soil Conservation Service, Mariposa County

Glen Marcussen - City Manager, City of Coalinga

Glen Matteson - Kings County Planning Dept.

Morris A. Martin, Jr. - District Conservationist, USDA Soil Conservation Service, Fresno County

Kerry McCants - Planner, Fresno County Planning Department

Gloria S. McGregor - Assistant Planning Director, Tulare County Planning Department

James W. McCutchan - Building Engineer, Tulare County

Robert Merrill - Geology Department, Calif. State University at Fresno

William Newkirk - Planning Director, City of Tulare

Louis Ollivier - Civil Defense Coordinator, Kings County

Robert W. Palmer - District Conservationist, USDA Soil Conservation Service, Madera County

Douglas A. Powell, Jr. - Planner II, Tulare County Planning Department

Jack Reagan - Planner, City of Fresno Planning Department

H. Duane Smith - City Engineer - Administrator, City of Kerman

Arvey Swanson - Department of Water Resources State of California

Mike Unser - Associate Planner, City of Porterville

Jeffrey Dennis Webster - Planner, Council of Fresno County Governments

Walter Wong - Engineer, City of Fresno

Tulare County
Association of Governments

ROOM 107 COURTHOUSE • VISALIA, CALIFORNIA 93277 • PHONE (209) 732-5511, EXT. 341

April, 1974

Robert E. Harrell, Chairman
Five County Seismic Safety Study Policy Committee
Tulare County Courthouse
Visalia, California 93277

Dear Mr. Harrell:

The Technical Committee of the Five County Seismic Safety Study has reviewed the work of the consultant, ENVICOM Corporation and their subcontractor, Quinton/Redgate. The Technical Committee, composed of representatives of the Council of Fresno County Governments, Kings County Regional Planning Agency, Madera County Planning Department, Mariposa County Planning Department, and the Tulare County Association of Governments has found the work completed to be satisfactory in that it (1) meets contractual obligations; (2) meets the requirements of the State of California for the Seismic Safety Element of the General Plan; and (3) meets all requirements of the Technical and Policy Committees.

Due to the rapid increase in knowledge regarding seismic conditions in California; changing requirements in planning law; and the need for continuity between planning elements as they are updated, we recommend that this report be considered as a benchmark in the continual upgrading of the Statewide effort towards provision of safety standards. These standards are absolutely necessary if we are to avoid the catastrophic effects of earthquakes, such as the ones that occurred at San Fernando in 1971, Long Beach in 1933, and San Francisco in 1906.

The members of the Technical Committee wish to express their appreciation to you for your leadership and constructive advice during the course of the study.

Cordially,

TULARE COUNTY ASSOCIATION OF GOVERNMENTS
Robert L. Wall, Executive Secretary

King Patrick Leonard, AIP
Chairman, Technical Advisory Committee

KPL:jm

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I INTRODUCTION

A. SCOPE OF INVESTIGATION

Section 65302 (f) of the Government Code requires a Seismic Safety Element of all city and county general plans as follows:

> "A seismic safety element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves such as tsunamis and seiches.
>
> The seismic safety element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves."

The Guidelines (Council on Intergovernmental Relations, 1973) for the preparation of local general plans states that:

> "The intent is that <u>all</u> seismic hazards are to be considered, even though only ground and water effects are given as specific examples. The basic objective is to reduce loss of life, injuries, damage to property, and economic and social dislocations resulting from future earthquakes."

Based on the interpretation of the intent of the law, the Guidelines define the scope of the Element as including:

1. A general policy statement.
2. The identification, delineation and evaluation of natural seismic hazards.
3. The consideration of existing structural hazards.
4. An evaluation of disaster planning program.
5. The determination of specific land use standards related to level of hazard and risk.

The Guidelines recognize that "local planning agencies may wish to consider the preparation of the Element or portions of the Element in joint action" and that "this would be particularly practical for the study of natural seismic hazards." With this suggestion in mind, the Seismic Safety Element for the Five-County area has been prepared as two documents. Those parts of the overall study that are specifically related to, and therefore adoptable by, an individual county can be included in the Element for a county or city. On the other hand, the technical investigation of the natural seismic hazards (Item 2 above), which is most efficiently handled on a joint basis, is included as this separate volume covering the entire Five-County area.

The Guidelines indicate that the identification of natural seismic hazards should include the following:

"1. General structural geology and geologic history.

2. Location of all active or potentially active faults, with evaluation regarding past displacement and probability of future movement.

3. Evaluation of slope stability, soils subject to liquefaction and differential subsidence.

4. Assessment of potential for the occurrence and severity of damaging ground shaking and amplifying effects of unconsolidated materials.

5. Identification of areas subject to seiches and tsunamis.

6. Maps identifying location of the above charactistics."

The following technical evaluation is intended to meet or exceed these requirements.

The investigation was begun in July of 1973, and has consisted primarily of the review, compilation, analysis, and hazard-related evaluation of published and unpublished data relevant to the Five-County area. The velocity data used in the analysis of near-surface amplification was contributed by the Standard Oil Company of California, and much difficult-to-obtain material was made available by local representatives of County, State and Federal agencies. The slope-stability analysis is based on the study of stereoscopic pairs of aerial photographs provided by the county representatives of the Soil Conservation Service.

The primary emphasis in the study has been placed on an analysis of expected ground shaking because the seismic setting of the area indicates this is the principal hazard. The methodology employed is that normally reserved for the analysis of sites for high-rise structures, and it has been used herein to calibrate the necessarily more generalized zonation of the area. This analysis was made possible by the contribution of the velocity data by Standard Oil, and by the availability of the computer programs for multi-layer analysis developed by the Earthquake Engineering Research Institute at U.C.L.A.

The basic map scale used in the investigation and in the presentation of results herein is 1:250,000 (1" = 4 miles), and available data appropriate to such a scale has been utilized where available. The distribution of seismic/geologic hazards and microzones as shown is considered appropriate to the scale used, but local variations that may affect conditions at an individual site may be present.

B. PHILOSOPHY OF THE ANALYSIS

The quantitative study of the strong shaking of earthquakes is a relatively young science. It was begun in California in the early 1930's, but has been limited by the necessity of having the right instruments in the right place when a significant earthquake does occur. Much information has been acquired over the last 40 years, but there are significant gaps and much remains to be learned.

With this relatively limited level of basic data, two different approaches to the development of a Seismic Safety Element are available. One can utilize broad generalizations to describe expected events; certainly the inadequacies of the data favor this approach. On the other hand, if the results are to be used by engineers in designing safer structures, then a commitment to mathematical form is necessary. To this end, the analysis is developed in this way, whenever possible, and presented in chart or graph form. Qualitative descriptions of the results are included for the lay reader, and a brief discussion of methodology, terminology and concepts is included in Section D.

The basic philosophy within which this analysis has been developed is that the intent of the Seismic Safety Element is to plan and prepare for the future based on what we know today rather than waiting until we know all that we would like to know.

C. CONCEPTS, METHODOLOGY AND TERMINOLOGY

1. General Statement

The Seismic Safety Element is probably the most technically-oriented of all the mandated elements of the General Plan. For this reason, and because of the wider range of backgrounds and experience of expected readers, it is appropriate to include in the Introduction a discussion of concepts, methodology and terminology to be used in developing the technical base for this element. This discussion is intended to supply not only a dictionary function of technical terms and concepts, but, most important, to establish the systematic cause-and-effect relationships between the several seismic hazards, and the need for a systematic analysis of available information.

The topics discussed in the following sections of the Introduction are arranged in an order that becomes increasingly more difficult for the layman to understand. Sections 2 through 4 discuss concepts and terms commonly included in newspaper accounts of earthquakes, while later sections discuss the concepts necessary in the technical analysis of earthquake hazards. The latter are intended primarily for readers with engineering or scientific backgrounds, but may also be of interest to the lay reader.

The text of the report is arranged in a similar order. Each section becomes increasingly more complex, and the later sections are intended to document the analysis for engineers and earth scientists who may wish to expand on or apply the data to the detailed analysis of individual sites.

2. Types of Hazards

The several seismic hazards discussed in the C.I.R. Guidelines can be grouped as a cause-and-effect classification that is the basis for the order of their consideration. Earthquakes originate as the shock wave generated by movement along an active fault. The primary natural hazards are ground shaking and the potential for ground rupture along the surface trace of the fault. Secondary natural hazards result from the interaction of ground shaking with existing ground instabilities, and include liquefaction, settlement, and landslides and seiches (waves in lakes or reservoirs). In this context, tsunamis, or "tidal waves", and seiches (often considered secondary hazards) would be primary natural hazards.

The potentially damaging natural events (hazards) discussed above may interact with man-made structures. If the structure is unable to accommodate the natural event, failure will occur. The potential for such failure is termed a structural hazard, and includes not only the structures themselves, but also the potential for damage or injury that could occur as the result of movement of loose or inadequately restrained objects within, on, or adjacent to a structure.

3. Active Faults - The Source of Earthquakes

Earth scientists are generally agreed that earthquakes originate as the result of an abrupt break or movement of the rock in the relatively brittle crust of the earth. The earthquake is the effect of the shock waves generated by the break, much the same as sound waves (a noise) are generated by breaking a brittle stick. If the area of the break is small and limited to the deeper part of the crust,

the resulting earthquake will be small. However, if the break is large and extends to the surface, then the break can result in a major earthquake.

These breaks in the earth's crust are called faults. In California, faults are extremely common, and vary from the small breaks of an inch or less that can be seen in almost any road-cut, to the larger faults such as the San Andreas on which movement over many millions of years has amounted to hundreds of miles. In addition to the size of faults, their "age" is also important. Many large faults have not moved for millions of years; they are considered "dead" or no longer active. They were probably the source of great earthquakes millions of years ago, but are not considered dangerous today.

Since faults vary as to the likelihood of their being the source of an earthquake, considerable effort has, and is continuing to be expended by geologists and seismologists to determine and delineate the faults likely to generate significant earthquakes. The C.I.R. Guidelines define an active fault as one that "has moved in recent geologic time and which is likely to move again in the relatively near future. Definitions for planning purposes extend on the order of 10,000 years or more back and 100 years or more forward." Policies and criteria adopted by the State Mining and Geology Board on November 21, 1973, define an active fault, for purposes of the Alquist-Priolo Act, as one which has moved at the surface during Holocene time (last 11,000 years). The State Geologist, in response to the Alquist-Priolo Act, has approached the problem in terms of potentially active faults. These are defined as faults that exhibit evidence of movement at the surface during Quaternary time (last 3,000,000 years); except that any fault that has been shown by direct evidence to have not moved during Holocene time is considered inactive.

The approach used herein is essentially that of the State Geologist. That is, faults are considered as potentially active if they cut Quaternary rocks, and if it has not been shown that they do not cut Holocene rocks. In the review of available geologic maps and data for evidence bearing on this problem, some judgement has been used in evaluating the evidence. Geologic mapping is conducted at various scales and for many different purposes. Depending on the purpose and the interests of the geologists involved, mapping may or may not be useful as a source of evidence as to the state of activity of a fault. A local example is a fault mapped by Page and LeBlanc (1969) near the bedrock outcrops east of Fresno. While recent movement is suggested at one small locality, the fault is terminated near more extensive deposits that would establish the critical relationships if involved. Also, there is no discussion of the evidence for the fault in the text, and the cartographic detail leaves considerable to be desired. The study was conducted to evaluate groundwater conditions in the Fresno area. It is useful for the purpose for which it was intended, but it is of minimal value in evaluating recency of faulting.

A similar problem exists with respect to the scattered earthquake epicenters that exist in most parts of California. There is a general association of earthquake epicenters and active faults, but there also exists a general "background" that increases in number of events near the major faults. The scattered epicenters in the western Sierra Nevada and eastern San Joaquin Valley are a local example. They increase in number toward the Owens Valley fault zone, and their distribution (discussed further in text of report) suggests they are related to faulting in the Owens Valley rather than near any one of the individual epicenters.

One such event was the earthquake that occurred during the course of this study (Sept. 14, 1973) near the town of Reedley. The Richter magnitude was 4.2, but shaking was pronounced near the epicenter because of the unusually shallow focal depth (approx. 4 km). While this earthquake is considered a significant event by the residents of the area near the epicenter, it is not given greater consideration herein than any other earthquake of this magnitude that has occurred in the study area during the period of instrumental recording (about 40 years).

4. Describing an Earthquake

Several terms are used to describe the location, "size", and effects of an earthquake. A clear understanding of the meaning of these terms and their limitations is essential to an understanding of the results of the investigation.

The location of an earthquake is generally given as the epicenter of the earthquake. This is a point on the earth's surface vertically above the hypocenter or focus of the quake. The latter is the point from which the shock waves first emanate. However, as discussed above, earthquakes originate from faults. These are surfaces not points, so the hypocenter is only one point on the surface that is the source of the earthquake.

Magnitude describes the size of the earthquake itself. Technically it is defined as the log of the maximum amplitude as recorded on a standard seismograph at 100 kilometers (62 miles) from the epicenter. The most important part of this definition is that it is a log scale; that is, an increase of 1 on the magnitude scale (e.g. magnitude 5.0 to 6.0) represents an increase of 10 in the amplitude of the recorded wave. It should also be noted that the magnitude of an earthquake is determined at a considerable distance from the center of the earthquake, and that it is based on ground displacement.

Intensity describes the degree of shaking in terms of the damage at a particular location. The scale used today is the Modified Mercalli Scale, and is composed of 12 categories (I to XII) of damage as described in Table 1.

The Roman numerals are used to emphasize that the units in the scale are discrete categories rather than a continuous numerical sequence as is the magnitude scale. It is important to remember that intensity is a very general description of the effects of an earthquake, and depends not only on the size of the quake and the distance to its center, but also on the quality of the construction that has been damaged and the nature of local ground conditions.

5. Occurrence, Recurrence and Risk of Earthquakes

Earthquakes have had in the past a certain occurrence in space and time. These occurrences may or may not set certain patterns that can form the basis for predicting their occurrence in the future. When such occurrences are analyzed in time, certain characteristics may statistically recur at definite intervals. If it can be shown that a particular magnitude earthquake recurs on a fault on the average of once in a certain time interval, then that interval is said to be the recurrence interval for that magnitude. Or, if the interval of time is set (e.g. a 100-year period), then earthquakes of a particular magnitude will recur a certain number of times in the specified period. This number is then the recurrence rate for that magnitude.

In California, small earthquakes occur much more often than large earthquakes. Also, there is a fairly definite pattern in that the log (base 10) of the number of events of a particular magnitude that have occurred in the past is inversely proportional to the magnitude of those events. This relationship appears to apply to larger areas such as California and western Nevada, some smaller areas such as the Los Angeles Basin, and to some faults such as the Newport-Inglewood. However, this relationship does not apply to all faults, and it should be applied to small areas, such as cities or individual sites, with great care.

Recurrence intervals can be used to indicate the risk of earthquake in much the same way that recurrence is used to describe the risk of flooding (e.g. 100-year flood). There is one important difference, however. Flood is the result of a random combination of meteorlogical events, whereas current geologic theory indicates that the buildup of the strain released during an earthquake is more likely to be regular. This regularity suggests that prediction, to varying degrees, may be possible depending on the extent of understanding of a particular fault. In some cases this understanding is limited to a statistical regularity in the number and magnitude of earthquakes generated. For others, such as the San Andreas fault, much more is known on which to base an estimate of the risks involved. For others, little more is known other than that there is some degree of hazard involved.

6. Acceleration, Velocity and Displacement

The data of seismologists and geologists are, in general, not applicable to the engineering design of earthquake-resistant structures. The seismograph, for example, is a very sensitive instrument designed to record earthquakes at great distances. A level of shaking that would be meaningful to an engineer in designing a building would put most seismographs completely off-scale.

As a result, it has been necessary to design and install special instruments to record the strong motions of earthquakes that are of interest to the engineer in the design of earthquake-restraint structures. The first such instruments, principally accelerographs and seismoscopes, were installed by the U.S. Coast and Geodetic Survey in the late 1920's. Since that time, the instrumentation and analytical techniques have been continuously improved, and many excellent records have been obtained of the more recent strong earthquakes.

The following sections are a brief introduction to the concepts, data and application of strong-motion records. The science is relatively young, and is growing in bursts that follow the recording of a damaging earthquake.

The accelerograph is a short-period instrument (in contrast to the seismograph), and measures the acceleration of the ground or the structure on which it is mounted. Figure 1 shows the ground acceleration recorded just a few hundred feet from the causative fault during the 1966 earthquake centered near Parkfield in southeast Monterey County. The velocity and dis-

TABLE 1.
MODIFIED MERCALLI INTENSITY SCALE OF 1931
(from United States Earthquakes, U.S. Dept. of Commerce)

Intensity	Description of Damage
I	Not felt except by a very few under specially favorable circumstances. (I Rossi-Forel Scale)
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel Scale)
III	Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale)
IV	During the day, felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale)
V	Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale)
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale)
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerably in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale)
VIII	Damage slight in specially designed structures; considerable in ordinary, substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII to IX Rossi-Forel Scale)
IX	Damage considerable in specially designed structures; well-designed, frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX Rossi-Forel Scale)
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with their foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale)
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into air.

placement curves have been derived from it by integration. It is a particularly good example of the relationships of these three parameters of motion because of the relatively "clean", single-displacement pulse that corresponds to two velocity peaks and four acceleration peaks. Figure 2 shows the more typically complex record of the San Fernando earthquake as recorded at Pacoima Dam.

Neither of the two, however, are typical records in terms of accelerations recorded. The Pacoima record shows the largest acceleration recorded to date (1.25g), and the Parkfield record (0.5g) was the largest recorded in the United States before the San Fernando earthquake.

It should be noted that accelerographs normally record three components; two in the horizontal plane at a right angle to each other, and one vertical. One component from the records of each of these two earthquakes is included as an example of this type of record.

Maximum acceleration is one of the basic parameters describing ground shaking, and has been the one most often requested by agencies such as FHA in determining the earthquake hazard to residential structures. It is particularly important for "low-rise" construction (one to five stories) and other structures having natural periods in the range of 0.3 - 0.5 seconds or less.

7. Frequency Content - Fourier and Response Spectra

The frequency content of the ground motion is particularly important for the intermediate and higher structures. The problem can be compared to pushing a child in a swing. If the pushes are timed to coincide with the natural period of the swing, then each push makes the swing go higher. However, if the timing is not right, then most of the push is lost "fighting" the natural period of the swing. The situation is similar during earthquakes. Structures have certain natural periods of vibration. If the pulses of the earthquake match the natural period of the structure, even a moderate earthquake can cause damaging movement. However, if the match is poor, the movement and resulting damage will probably be much less.

Two methods are commonly used to analyze and display the frequency content of an earthquake. A Fourier analysis is a common mathematical method of deriving the significant frequency characteristics of a time-signal such as the record of an earthquake. The results of the analysis are an amplitude term and a phase term. The amplitude is normally plotted against the period for that amplitude to give a Fourier amplitude spectrum for the range of frequencies that are of interest. Since the mathematical procedure is basically an integration of acceleration with time, the Fourier amplitude has the units of velocity.

A response spectrum is derived by a similar mathematical process, but is slightly different in concept. It represents the maximum response of a series of oscillators, having particular periods and damping, when subjected to the shaking of the earthquake. The result is also expressed in terms of velocity with the particular nomenclature depending on the precise method used to derive the spectrum.

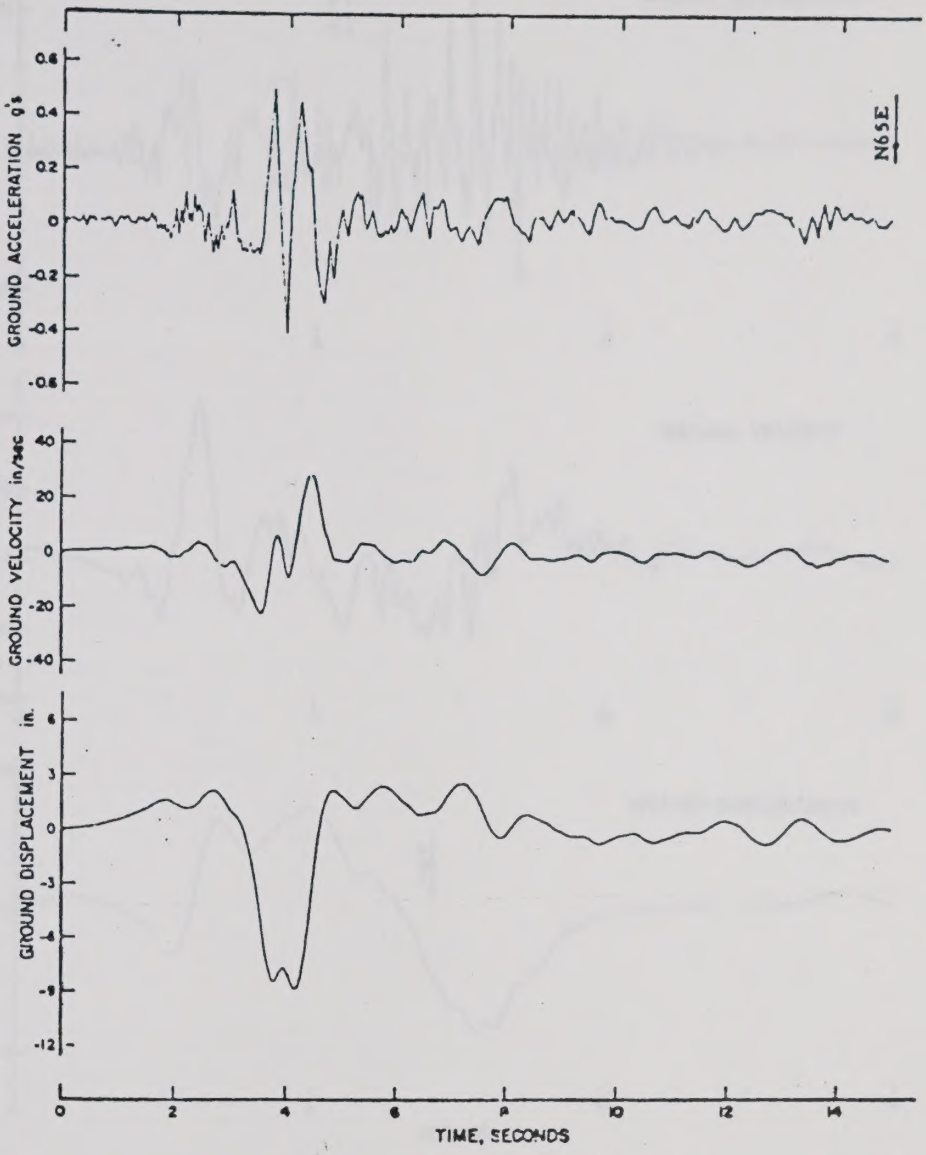
The Fourier spectrum can be generally described as a display of the energy available to shake structures having various natural frequencies. The response spectrum gives the effect, in maximum velocity, of this available energy on simple structures having various frequencies and damping. At zero damping the two are very similar. Figure 3 shows a plot of both the Fourier spectrum and the response spectrum with zero damping for the Taft, California record of the 1952 Kern County earthquake. Figure 4 shows the response spectrum for the Parkfield, California record (Figure 1) for several levels of damping.

8. Near-Surface Amplification

The shock waves of an earthquake radiate outward from the source (i.e. the slipped fault) through the deeper and relatively more dense parts of the earth's crust. In this medium, the waves travel at high velocity and with relatively low amplitude. However, as they approach the surface, the velocity of the medium decreases and may become quite variable if layers of different rock types are present. The overall effect is generally an amplification of the wave or of certain frequencies within the spectrum of the wave.

The most consistently applicable effect is the increase in wave amplitude that accompanies the decrease in velocity. This relationship can be compared to laws of mechanics that require the conservation of energy and momentum. In the case of earthquake waves, the energy of velocity is transferred to energy of wave amplitude when the velocity decreases.

A second effect is the amplification of certain frequencies due to the thickness and velocity of near-surface layers of the earth. The geometry of these layers controls the frequency of shaking just like the geometry of a TV antenna controls the frequency it receives best. A striking example is the very high amplification of



Station 2 N65E Motion.

FIGURE 1. Ground acceleration, velocity and displacement. 1966 Parkfield earthquake.

from Housner & Trifunac, 1967.

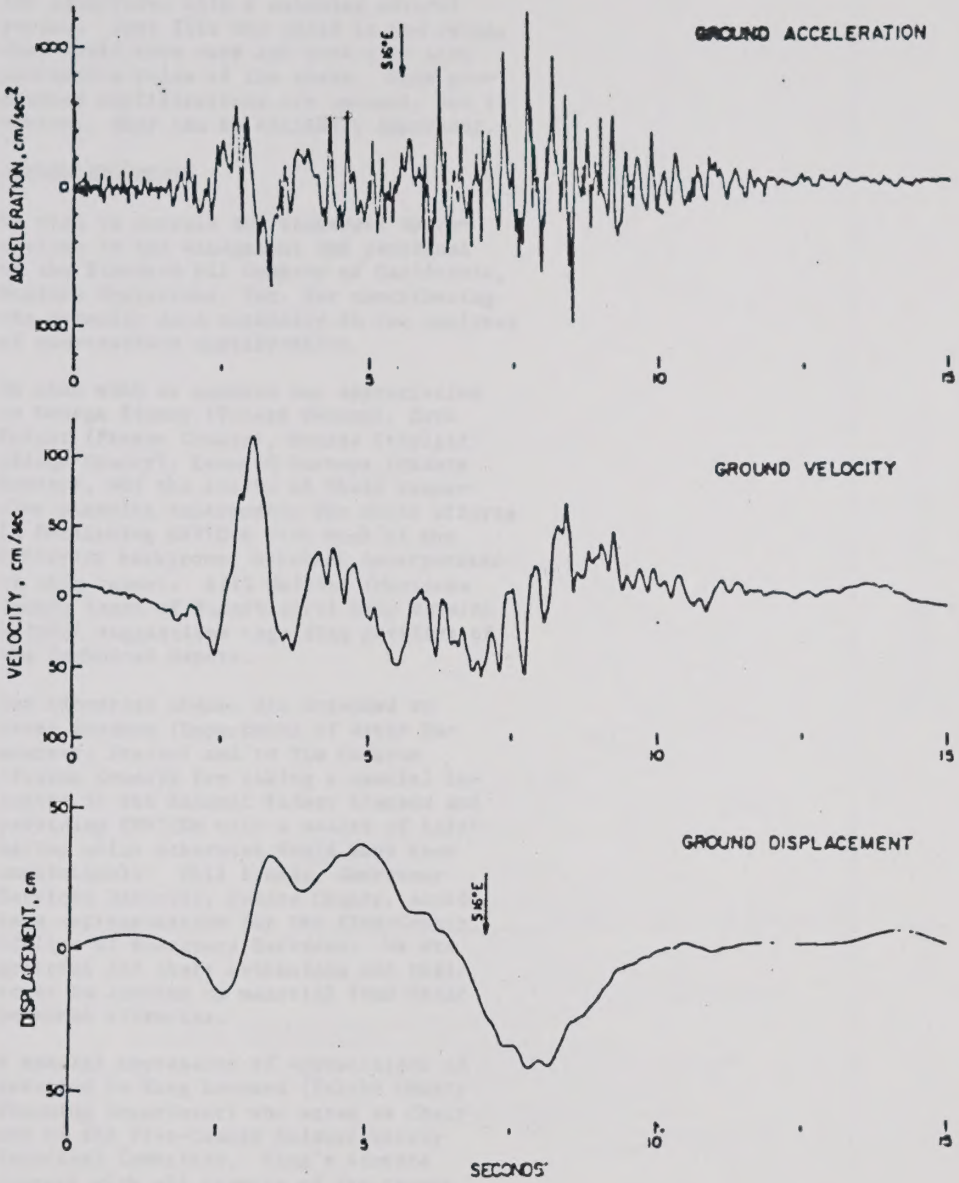


FIGURE 2. Acceleration, velocity and displacement in the S16° E direction during the main event of the San Fernando earthquake of February 9, 1971, 06:00 (PST).

from Trifunac & Hudson, 1971.

waves of 2.5-second period (Figure 5) by the stratification of the old lake beds on which Mexico City has been built. This concentration of the energy in a very narrow frequency range could be disastrous for structures with a matching natural period. Just like the child in the swing, they would move more and more with each successive pulse of the quake. Such pronounced amplifications are unusual, but if present, they can be extremely important.

D. ACKNOWLEDGEMENTS

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We are grateful to the United States Soil Conservation Service for providing us with excellent aerial photo coverage of the study area. Particular thanks are extended to the District Conservationists: Morris Martin (Fresno County), Bill Bruner (Tulare County), Ernie Eaton (Kings County), Bob Palmer (Madera County), and Don Lucas (Mariposa County), for their interest in the project.

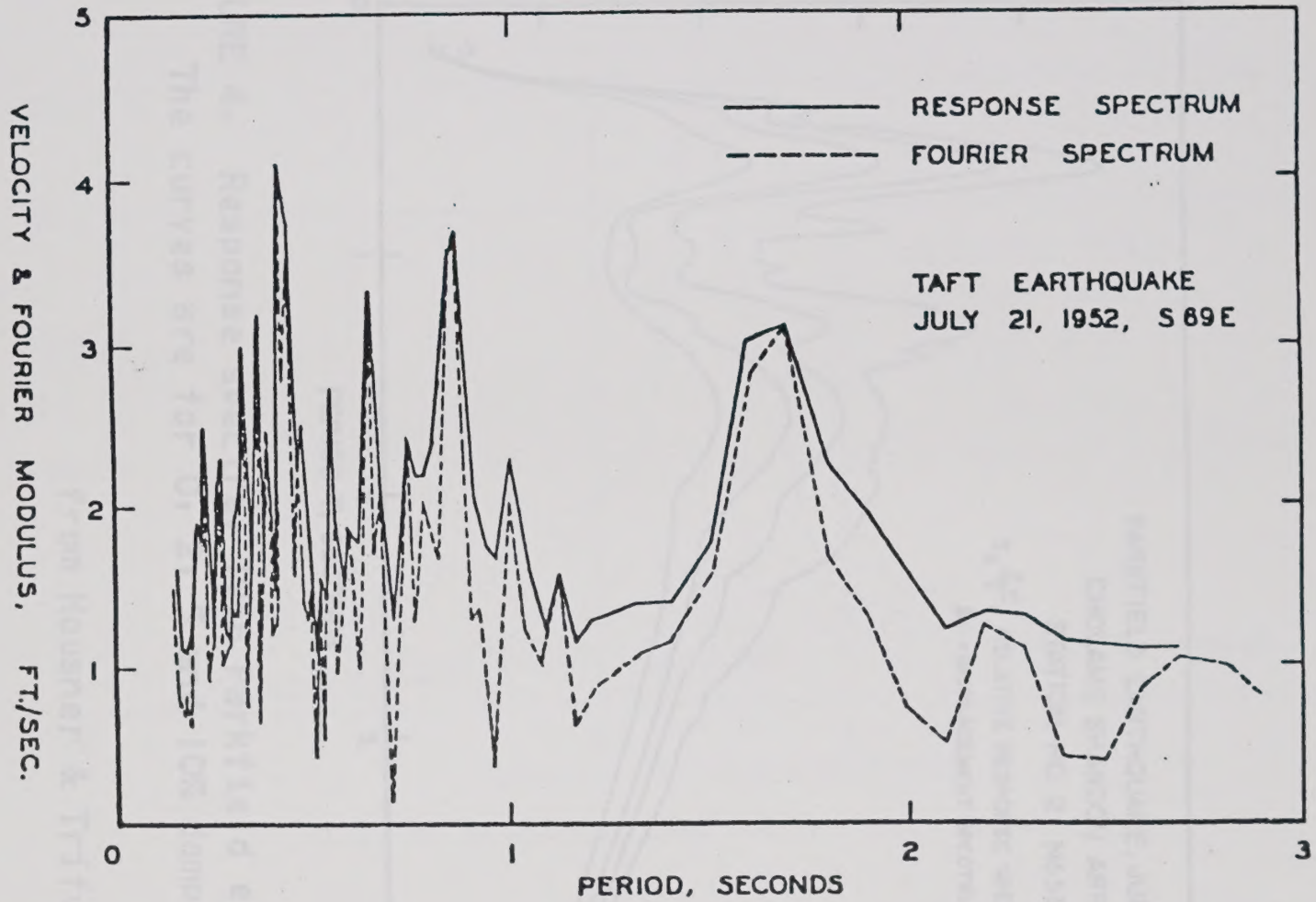


FIGURE 3. Fourier and response spectra, 1952 Kern County earthquake.

from Alford et al, 1964.

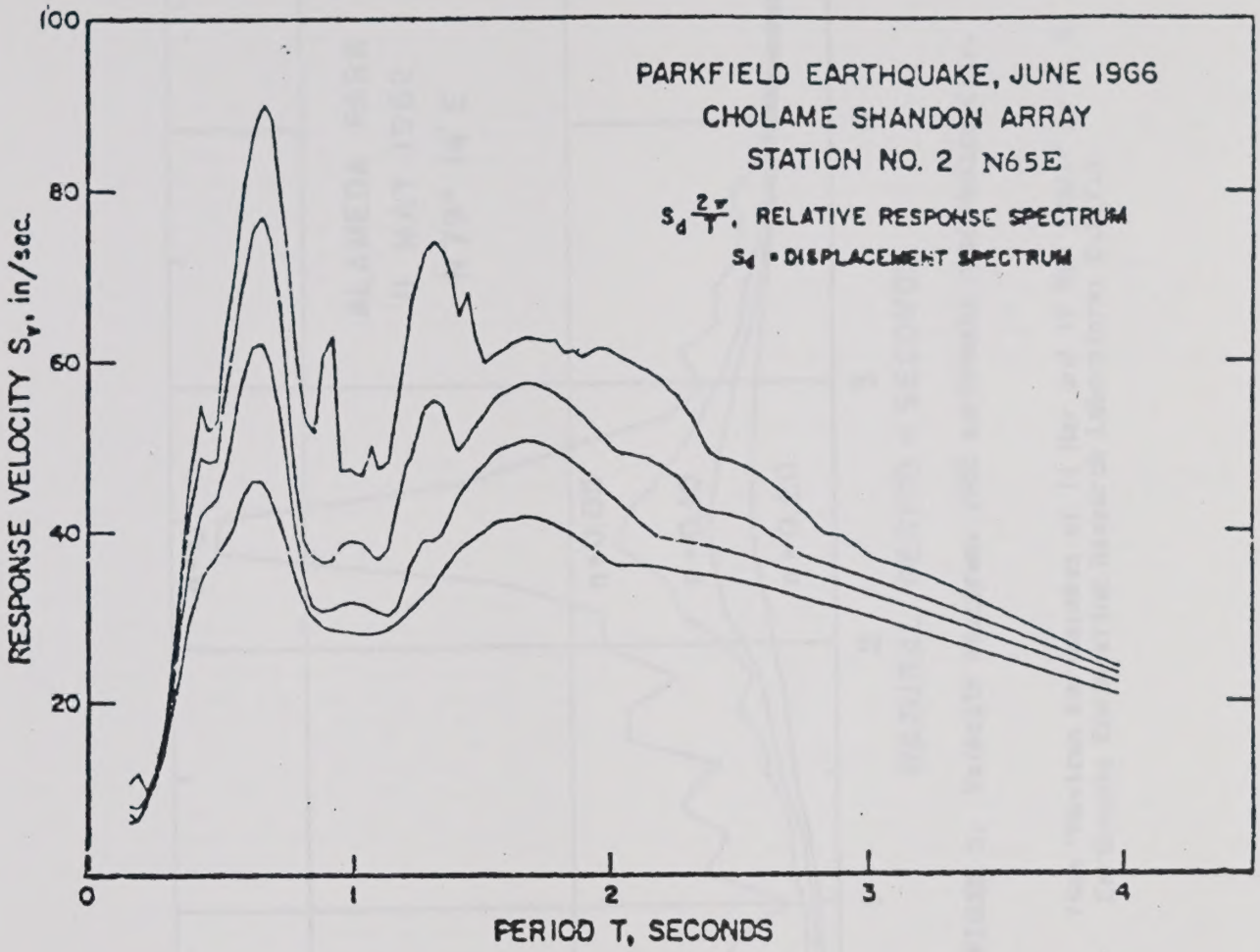


FIGURE 4. Response spectra, 1966 Parkfield earthquake. The curves are for 0, 2, 5 and 10% damping.

from Housner & Trifunac, 1967.

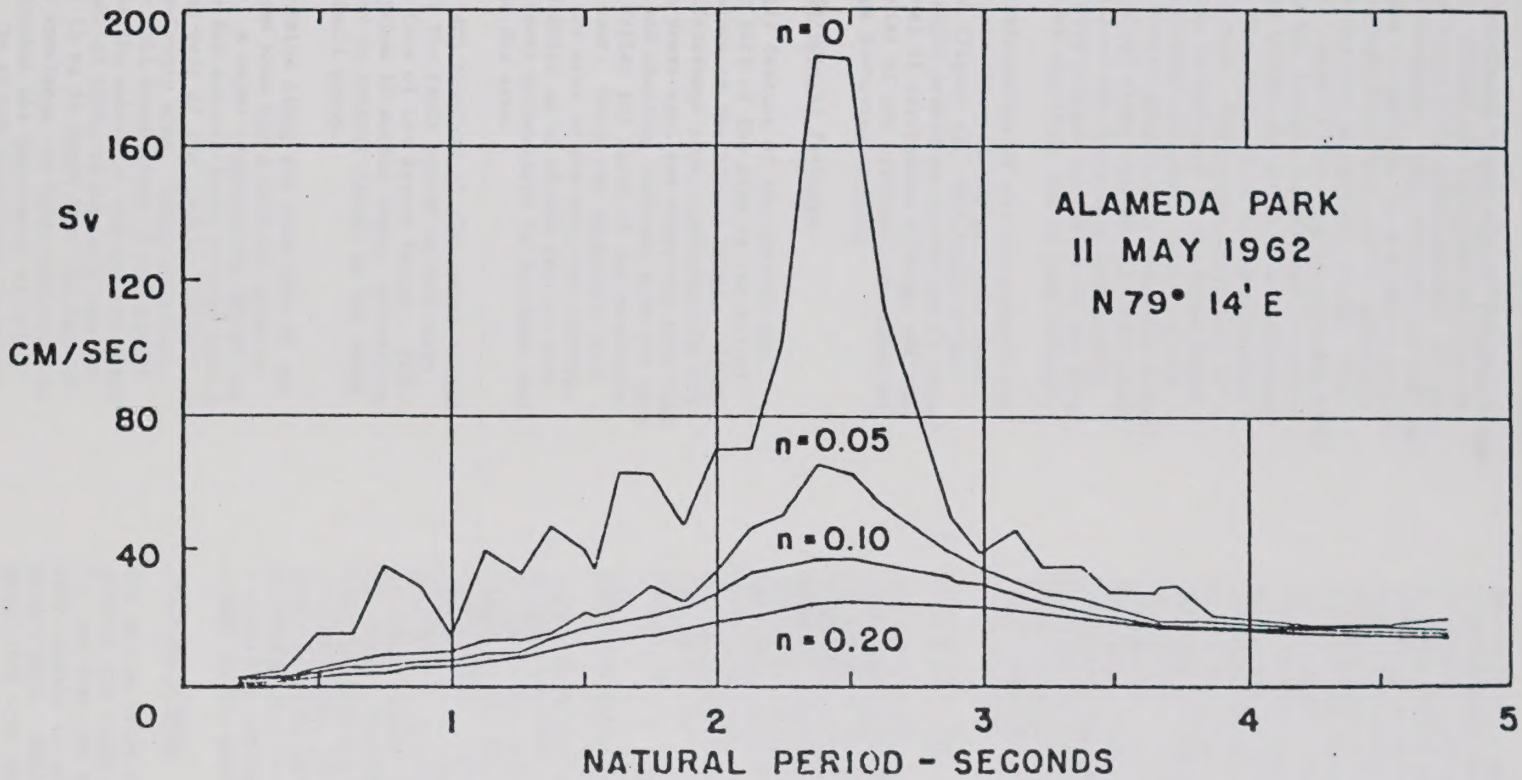


FIGURE 5. Velocity spectrum, 1962 earthquake near Mexico City.

(See "Mexican Earthquakes of 11 May and 19 May 1962," by P. C. Jennings, Earthquake Engineering Research Laboratory, C.I.T.)

A. GEOLOGIC AND SEISMIC SETTING

1. Major Physiographic and Geologic Provinces

The Five-County study area of Tulare, Kings, Fresno, Madera and Mariposa Counties includes three major physiographic and geologic provinces. The northeastern half of the area is included in the Sierra Nevada physiographic province and is underlain by igneous and metamorphic rocks. The central third of the area is included within the San Joaquin Valley, and is underlain by marine and non-marine sedimentary rocks to a depth of up to approximately 18,000 feet. The southwestern part of the area is included in the Coast Range physiographic province. Rocks in this area consist primarily of complexly folded and faulted older (Eocene and Cretaceous) sedimentary and Franciscan metamorphic rocks with younger sediments on the lower slopes of the hills and in some valleys.

The relationships of the three major provinces are shown on the geologic cross section (Figure 6). The rocks of the three major provinces significantly affect the level of earthquake shaking, and the boundaries of the provinces are shown on all maps involving shaking.

2. Major Structural Features

The major feature of the central and eastern part of the area is the tilted fault block of the Sierra Nevada. Since lower Cretaceous time, approximately 100 million years ago, the mountains have been rising and shedding sediment into the area of the Valley and parts of the mountains to the west. While the mountains were rising the area to the west was sinking, and sediments up to 18,000 feet or more in thickness accumulated in the seas that occupied the area.

The eastern boundary of this major tilted block is the fault system on the steep, eastern face of the Sierra Nevada. This fault system is active today, and will be discussed in greater detail as the Owens Valley fault group.

The mountains along the west side of the study area have had a long and complex history. A major complicating factor has been the San Andreas fault located just a few miles west of the western boundary of the Five-County area. While this fault has been well known since it was established as the source of the San Francisco earthquake of 1906, it has only been in the last 15 to 20 years that the mass of geologic knowledge has been sufficient to fully document the importance of this feature. It is now known that it is not only an important source of earthquakes, but that movement along this fault has amounted to hundreds of miles. These major features and their impact on seismic safety in the Five-County area are discussed in greater detail in the following sections of this report.

B. ACTIVE AND POTENTIALLY ACTIVE FAULTS

1. General Statement

Active faults that are known to be capable of generating earthquakes of magnitude 6 or greater, or those that are considered as potentially capable of generating earthquakes of this magnitude because of their length and geologic history, must be considered both as the location of surface rupture and/or the source of damaging earthquakes. This section of the report will discuss all known active or potentially active faults within the study area, and all major active faults sufficiently close to the study area to be the source of damaging earthquakes within the Five-County area. The purposes of this discussion are to delineate any faults within the area that should be considered as hazardous from the standpoint of surface rupture, and to establish those faults which will require further analysis of their capacity to generate damaging earthquake shaking.

2. San Andreas Fault

The San Andreas fault is probably the most important fault in determining the level of the hazard from ground shaking in the Five-County area. The long history of movements and earthquakes on this fault indicates that it is the most likely source of a damaging earthquake for most of the area. However, the San Andreas fault is not located within the Five-County area (Figure 7), so it is not a hazard with respect to ground rupture.

3. Owens Valley Fault Group

A complex group of faults located along or near the base of the steep, east slope of the Sierra Nevada (near fault 7 on Figure 7) is herein termed the Owens Valley fault group. All known active or potentially active faults within the group are east of the Five-County area, and do not present a hazard from ground rupture in the area. However, this fault group has been the source of numerous earthquakes in historic time, including the "great" earthquake of 1872, and it must be considered as second only to the San Andreas fault as a source of earthquakes that could cause damage in the area.

4. White Wolf Fault

The active White Wolf fault is also located outside the study area (fault 18 in Figure 7), and does not appear to be a hazard with respect to ground rupture in the Five-County area. This fault was little known until 1952 when movement along it generated the damaging series of earthquakes of that year in the Bakersfield area. The shaking from this series of shocks was the most severe in the Five-County area since the detailed compilation of intensity data was begun by the Coast and Geodetic Survey in 1928.

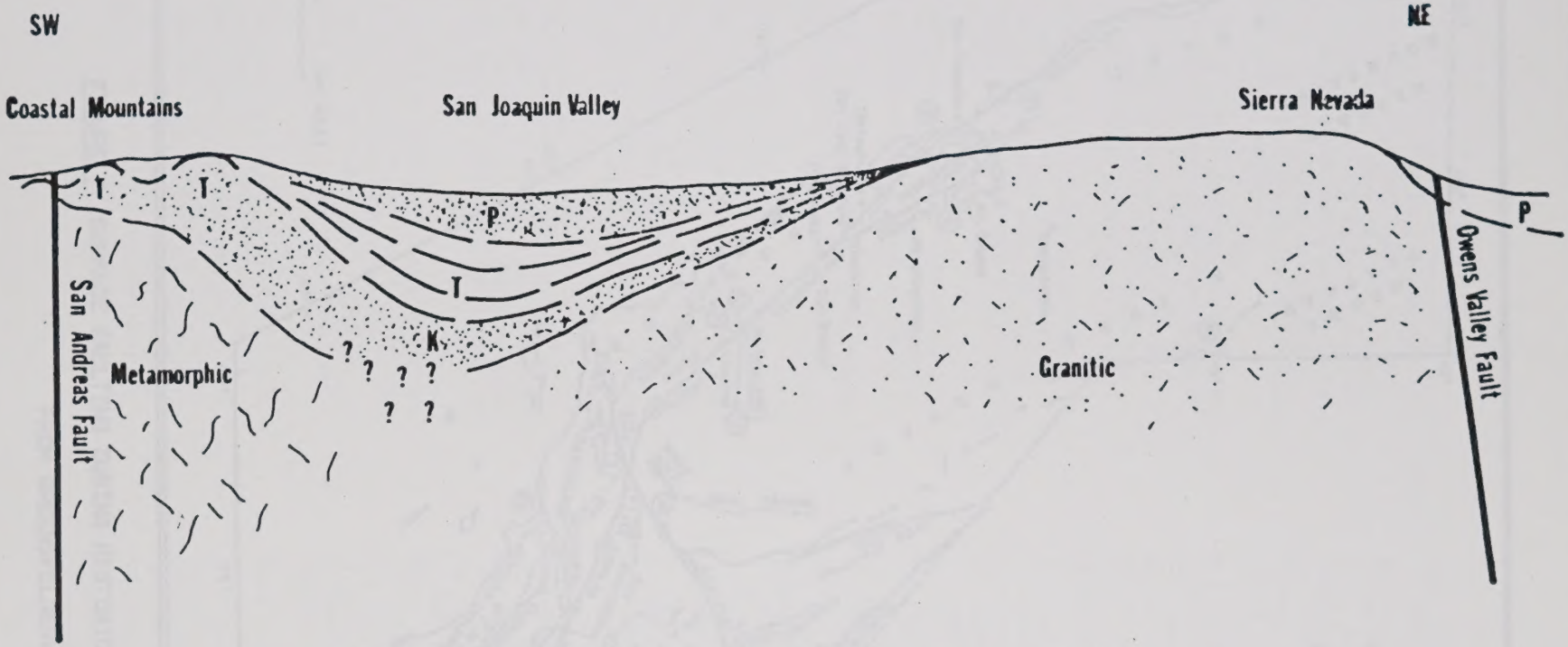


FIGURE 6 GENERALIZED GEOLOGIC CROSS SECTION. P = PLIO-PLEISTOCENE ROCKS; T = MIDDLE AND LOWER TERTIARY ROCKS; AND K = UPPER CRETACEOUS ROCKS.

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

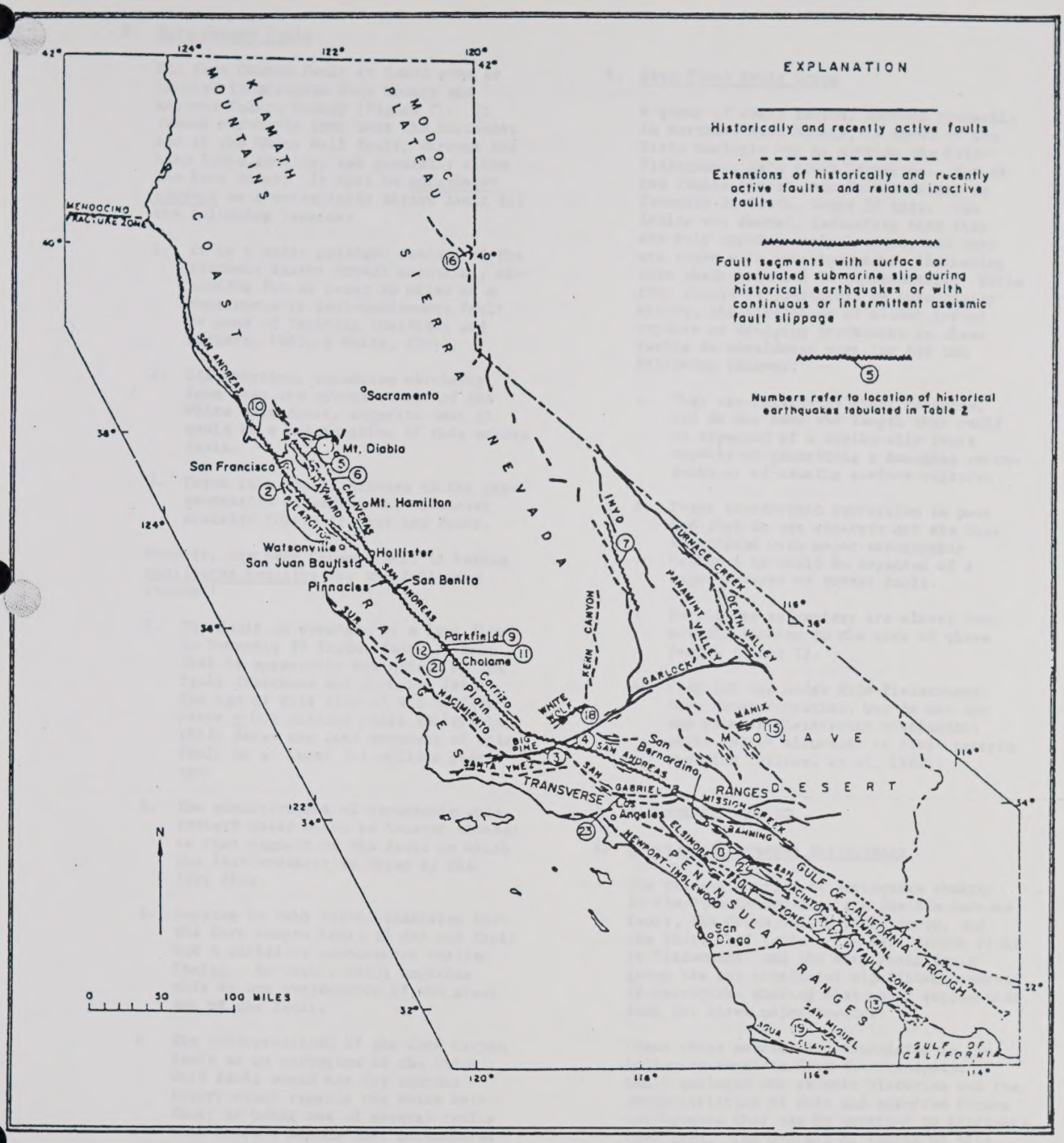


FIGURE 7 SURFACE FAULTING DURING HISTORIC EARTHQUAKES.

FROM GREENSFELDER, 1972.

5. Kern Canyon Fault

The Kern Canyon fault or fault zone is located in northern Kern County and eastern Tulare County (Figure 7). It trends northerly from near the northeast end of the White Wolf fault, through the Lake Isabella area, and generally along the Kern River. It must be considered suspect as a potentially active fault for the following reasons:

1. It is a major geologic feature of the southern Sierra Nevada mountains, extending for at least 80 miles as a continuous or semi-continuous fault or zone of faulting (Matthews and Burnett, 1965, & Smith, 1964).

2. Its location, extending northerly from near the northeast end of the White Wolf fault, suggests that it could be a continuation of this active fault.

3. There is a local increase in the concentration of earthquake epicenter activity (Plate I) near the fault.

However, the Kern Canyon fault is herein considered inactive for the following reasons:

1. The fault is overlain by a lava flow in Township 20 South, Range 33 East that is apparently not offset by the fault (Matthews and Burnett, 1965). The age of this flow of 3.5 million years $\pm$ 0.1 million years (Dalrymple, 1963) dates the last movement of this fault as at least 3.4 million years ago.

2. The concentration of earthquake epicenters noted above is located closest to that segment of the fault on which the last movement is dated by the lava flow.

3. Mapping by Webb (1946) indicates that the Kern Canyon fault is not one fault but a series of unconnected smaller faults. He (Webb, 1955) explains this as one consequence of the great age of the fault.

4. The interpretation of the Kern Canyon fault as an extension of the White Wolf fault would not fit current theory which regards the White Wolf fault as being one of several faults that relieve strain that accumulates near a major bend in the San Andreas fault.

6. Kern Front Fault Group

A group of small faults, located primarily in northern Kern County, is shown on the State Geologic Map as cutting the Plio-Pleistocene Kern River Formation. Two of the faults extend into Tulare County in Township 24 South, Range 27 East. The faults are dashed, indicating that they are only approximately located, and they are shown with question marks, indicating that their presence is questionable. While they should be considered as potentially active, the likelihood of either ground rupture or damaging earthquake on these faults is considered very low for the following reasons:

1. They are relatively short features, and do not have the length that would be expected of a strike-slip fault capable of generating a damaging earthquake or of causing surface rupture.

2. Their topographic expression is poor and they do not separate nor are they associated with major topographic features as would be expected of a major reverse or normal fault.

3. Earthquake epicenters are almost completely lacking in the area of these faults (Plate I).

4. They cut the older Plio-Pleistocene Kern River Formation, but do not cut the younger Pleistocene continental units (older alluvium) or river terrace deposits (Hilton, et al, 1963).

C. EARTHQUAKE SHAKING

1. Sources of Expected Earthquakes

The primary sources of earthquake shaking in the Five-County area are the San Andreas fault, the Owens Valley fault group, and the White Wolf fault. The Kern Canyon fault or "lineament" and the Kern Front fault group are not considered significant sources of earthquake shaking that would exceed that from the three major sources.

These three sources are considered in the following sections from the standpoint of their geologic and seismic histories and the characteristics of past and expected future earthquakes that can be expected to originate from them. The overall objective of this analysis is to establish the risk of movement and the engineering characteristics of certain "design earthquakes" as they will affect the various parts of the Five-County area.

TABLE 2
TABULATED LIST OF HISTORICAL EARTHQUAKES SHOWN IN FIGURE 7

	Date and Fault	Earthquake Magnitude	Movement
1.	1836 - Hayward fault	7.0 ± 0.5 (est.)	Ground breakage
2.	1838 - San Andreas fault	7.0 ± 0.5 (est.)	Ground breakage
3.	1852 - Big Pine fault	no data	Ground breakage
4.	1857 - San Andreas fault	8.0 ± 0.5 (est.)	Right-lateral, possible as much as 30'
5.	1861 - Calaveras fault	no data	Ground breakage
6.	1868 - Hayward fault	7.0 ± 0.5 (est.)	Strike slip
7.	1872 - Owens Valley fault zone	8.3 ±	Down to E. 23'; right-lateral, 16' - 20', but some reports state left-lateral movement also occurred
8.	1899 - San Jacinto fault	6.6 ± 0.42	Surface evidence questionable
9.	1901 - San Andreas fault	6.3 ± 0.42	Ground breakage
10.	1906 - San Andreas fault	8.3	Right-lateral, 21'
11.	1922 - San Andreas fault	6.5	Ground breakage
12.	1934 - San Andreas fault	6.0	Ground breakage
13.	1934 - San Jacinto fault zone in Colorado River Delta	7.1	Distinct fault trace on 1935 aerial photographs
14.	1940 - Imperial fault	7.1	Right-lateral, 19'
15.	1947 - Manix fault	6.4	Left-lateral, 3"
16.	1950 - Unnamed fault along west edge of Fort Sage Mountains	5.6	Down to W. 5" - 8"
17.	1951 - Superstition Hills fault	5.6	Right-lateral, slight
18.	1952 - White Wolf fault	7.7	Reverse fault, south plate moved from SW to NE; left-lateral, 2'; throw 2'
19.	1956 - San Miguel fault	6.8	Right-lateral, 3'; down to SW 3'
20.	1966 - Imperial fault	3.6	Right-lateral, 1-1/2 cm
21.	1966 - San Andreas fault	5.5	Right-lateral, several inches
22.	1968 - Coyote Creek fault (San Jacinto fault zone)	6.5	Right-lateral, 33 cm.
23.	1971 - San Fernando fault	6.6	Left-lateral, 6'; reverse, 6'

From Greensfelder, 1972.

2. Recurrence of Earthquakes

a. Objective of Analysis

The basic objective of the analysis of the recurrence of earthquakes is to establish, as closely as possible with the information available, the approximate time span between earthquakes of various magnitudes originating on a particular fault. These time spans are called recurrence intervals, and they generally relate to the risk, or probability, of an earthquake occurring in a given period of time. For faults such as the San Andreas that have been intensively studied, the information can also be combined to indicate the approximate time of the next big earthquake. While such an interpretation is tempting, it should be avoided. The seismic record is simply not long enough to justify estimates of this type.

The recurrence of earthquakes of various magnitudes can be derived in at least three different ways:

1. The analysis of the seismicity of a fault may reveal relationships that indicate that, at least statistically, earthquakes of particular magnitudes recur at regular rates. Data suitable for this type of analysis is available for only about the last 40 years.

2. The measurement of the movement of the earth on either side of a fault, or crustal strain, can sometimes be derived from survey data. This information is available for a longer period of time, but movement is often so small it is not detectable from ordinary data. Very accurate surveys have been conducted in recent years, but across only a few faults. If the rate of accumulation of strain is known, then the amount of time necessary to accumulate the strain necessary for an earthquake of a particular magnitude can be estimated from other relationships.

3. The relationship of unique rock units on either side of a fault may yield the geologic slip rate if the ages of the unique units are known. The principal problem with this method is the assumption that rates obtained for a time span of several million, or several tens of millions, of years are valid today.

The applicability of any of the above methods depends on the data available. Of the faults pertinent to this investigation, the San Andreas is the best known, and data is available with which to utilize all three methods. Therefore, the San Andreas is considered first, as the results of this analysis will aid in evaluating the lesser known faults.

b. San Andreas Fault

1. Seismicity

As discussed earlier, the San Andreas fault varies as to its state of activity along its length from the Gulf of California to Cape Mendocino (Figure 8). The areas of differing activity bearing on this investigation are the 1857 Break and the Central California active area. The former is essentially "quiet" (i.e. devoid of significant earthquake activity), while the latter is the site of large numbers of earthquakes.

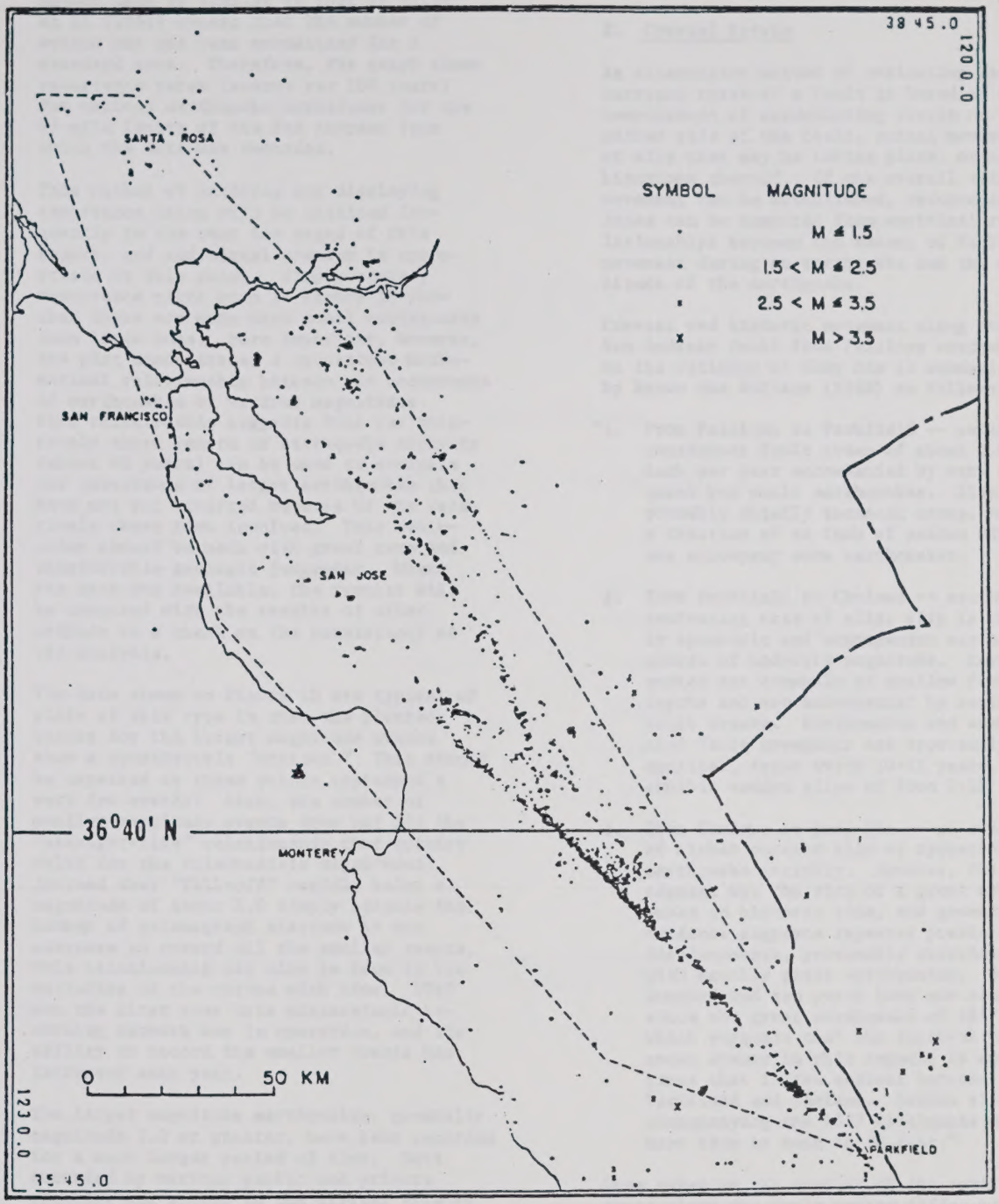
Records of earthquakes in the active area are of two different types. The University of California Seismographic Station at Berkeley has been recording the location and magnitude of earthquakes in this area since 1932. More recently, the U.S. Geological Survey in cooperation with other interested agencies set up a network of closely spaced seismographic stations between Cholame in San Luis Obispo County and the Bay Area. Since this data is more detailed, it is analyzed separately from that recorded by the regional stations. This more detailed data is referred to herein as "microseismic" data, while the regionally recorded data is referred to as "macroseismic" data.

Microseismic data for the San Andreas fault system in central California have been compiled for the period of 1969 through the first half of 1972 by Lee et al (1972A), Lee et al (1972B), Lee et al (1972C), Wesson et al (1972A), and Wesson et al (1972B). From this data, the number of earthquakes for each year that occurred between Cholame and Paicines (Latitude 35° 45' to 36° 40' N) are compiled by half magnitude intervals, and summarized in Table 3 as the number of events in that time interval and also as the number of events in an arbitrarily chosen, standard interval of 100 years. The data used were limited to the area south of Paicines because the fault system becomes very complex to the north. A map showing a typical distribution of microseismic events and the complexity of the pattern north of Latitude 36° 40' N is included as Figure 9.

TABLE 3
MICROSEISMICITY OF SAN ANDREAS FAULT
CHOLAME TO PAICINES (35° 45' to 36° 40' N. Lat.)

	Number of Events in Time Interval					Number of Events Per 100 Years				
Magnitude	1969	1970	1971	1st half 1972	1969 to 1st half 1972	1969	1970	1971	1st half 1972	1969 to 1st half 1972
0.0 - 0.4	7	18	-	57	82	700	1,800	-	11,400	2,343
0.5 - 0.9	17	53	92	489	651	1,700	5,300	9,200	97,800	18,599
1.0 - 1.4	40	188	299	672	1,199	4,000	18,800	29,900	134,400	34,255
1.5 - 1.9	97	229	295	410	1,031	9,700	22,900	29,500	82,000	29,456
2.0 - 2.4	77	103	131	225	536	7,700	10,300	13,100	45,000	15,314
2.5 - 2.9	29	41	38	48	156	2,900	4,100	3,800	9,600	4,457
3.0 - 3.4	8	12	21	23	64	800	1,200	2,100	4,600	1,828
3.5 - 3.9	2	5	4	8	19	200	500	400	1,600	543
4.0 - 4.4	2	1	0	0	3	200	100	0	0	86
4.5 - 4.9	0	0	0	1	1	-	-	-	200	29
5.0 - 5.4	0	0	0	1	1	-	-	-	200	29

from: Catalogues of earthquakes along the San Andreas fault system in Central California for the years: 1969, 1970, 1971, Jan - Mar 1972, Apr - June 1972; U.S.G.S. Open File Reports, 1972.



Source: From Lee et al, 1972C

FIGURE 9 SEISMIC EPICENTERS FOR 1971, SAN ANDREAS FAULT SYSTEM IN CENTRAL CALIFORNIA, SHOWING LINEAR PATTERN OF DISTRIBUTION IN AREA SOUTH OF 36° 40' N.

The data in Table 3 for the normalized 100-year interval are plotted on the graph, Figure 10, for each complete year and for the total 3.5 year interval. The method used is similar to that of Allen et al (1965) except that the number of events has not been normalized for a standard area. Therefore, the graph shows recurrence rates (events per 100 years) for various earthquake magnitudes for the 87-mile length of the San Andreas from which the data was recorded.

This method of deriving and displaying recurrence rates will be utilized frequently in the next few pages of this report, and additional comment is appropriate at this point. Simply stated, recurrence plots such as Figure 10 show that there are many more small earthquakes than large ones. More important, however, the plot demonstrates a consistent mathematical relationship between the occurrence of earthquakes of various magnitudes. This relationship suggests that our relatively short record of earthquake activity (about 40 years) can be used to evaluate the recurrence of larger earthquakes that have not yet occurred because of the relatively short time involved. This evaluation should be made with great care and considerable geologic judgement. Where the data are available, the results will be compared with the results of other methods as a check on the consistency of the analysis.

The data shown on Figure 10 are typical of plots of this type in that the plotted points for the larger magnitude events show a considerable "scatter." This should be expected as these points represent a very few events. Also, the number of smaller-magnitude events does not fit the "straight-line" relationship that appears valid for the intermediate magnitudes. Instead they "fall-off" rapidly below a magnitude of about 2.0 simply because the number of seismograph stations is not adequate to record all the smaller events. This relationship can also be seen in the variation of the curves with time. 1969 was the first year this microseismic recording network was in operation, and its ability to record the smaller events has increased each year.

The larger magnitude earthquakes, generally magnitude 3.0 or greater, have been recorded for a much longer period of time. Data recorded by various public and private agencies and stored in the digital file of the Berkeley Seismographic Station of the University of California are shown on Plate 1, and are tabulated for the Cholame to Paicines segment of the San Andreas fault in Table 4. The time interval for which magnitudes are available is 1932 through 1971, a period of 40 years. Display of the data is similar to that used for the microseismic data; recurrence rates are normalized to an interval of 100 years and plotted on Figure 11.

The recurrence rates from the macroseismic and the microseismic data will be compared as a part of the discussion of the results of various methods.

2. Crustal Strain

An alternative method of evaluating recurrence rates of a fault is based on the measurement of accumulating strain on either side of the fault, actual movement or slip that may be taking place, or combinations thereof. If the overall rate of movement can be established, recurrence rates can be computed from empirical relationships between the amount of fault movement during an earthquake and the magnitude of the earthquake.

Current and historic movement along the San Andreas fault from Paicines southward to the vicinity of Camp Dix is summarized by Brown and Wallace (1968) as follows:

"1. From Paicines to Parkfield -- relatively continuous fault creep of about 0.8 inch per year accompanied by very frequent but small earthquakes. Slip is probably chiefly tectonic creep, but a fraction of an inch of sudden slip may accompany some earthquakes.

2. From Parkfield to Cholame -- southward-decreasing rate of slip; slip is chiefly spasmodic and accompanies earthquakes of moderate magnitude. Earthquakes are commonly at shallow focal depths and are accompanied by surface fault breaks. Earthquakes and associated fault movements are apparently cyclical, recur every 10-15 years, and exhibit sudden slips of from 2-10 inches.

3. From Cholame to Camp Dix -- no evidence of either current slip or appreciable earthquake activity. However, this segment was the site of a great earthquake in historic time, and geomorphic evidence suggests repeated prehistoric displacements, presumably associated with equally great earthquakes. One hundred and ten years have now elapsed since the great earthquake of 1857, which suggests that the interval between events in this segment is many times that in the segment between Parkfield and Cholame. Sudden slip accompanying the 1857 earthquake may have been as much as 30 feet."

When taken in the context of the several areas along the fault having different types of activity (Figure 8), the segment south of Cholame is a part of the "1857 Break," and the segment north of Parkfield is part of the Central California active area. The segment between, from Cholame to Parkfield can be considered a transition zone with characteristics intermediate between the segments to the north and south.

TABLE 4
MACROSEISMICITY OF SAN ANDREAS FAULT
CHOLAME TO PAICINES (35° 45' to 36° 40' N. Lat.)
1932 through 1971

Magnitude	Number of Events 1932-1971	Per 100-years
2.0-2.4	35	87.5
2.5-2.9	82	205.0
3.0-3.4	460	1150.0
3.5-3.9	181	452.5
4.0-4.4	80	200.0
4.5-4.9	30	75.0
5.0-5.4	13	32.5
5.5-5.9	4	10.0
6.0-6.4	1	2.5

from: University of California, Berkeley Seismographic Station digital data file, searched July 30, 1973.

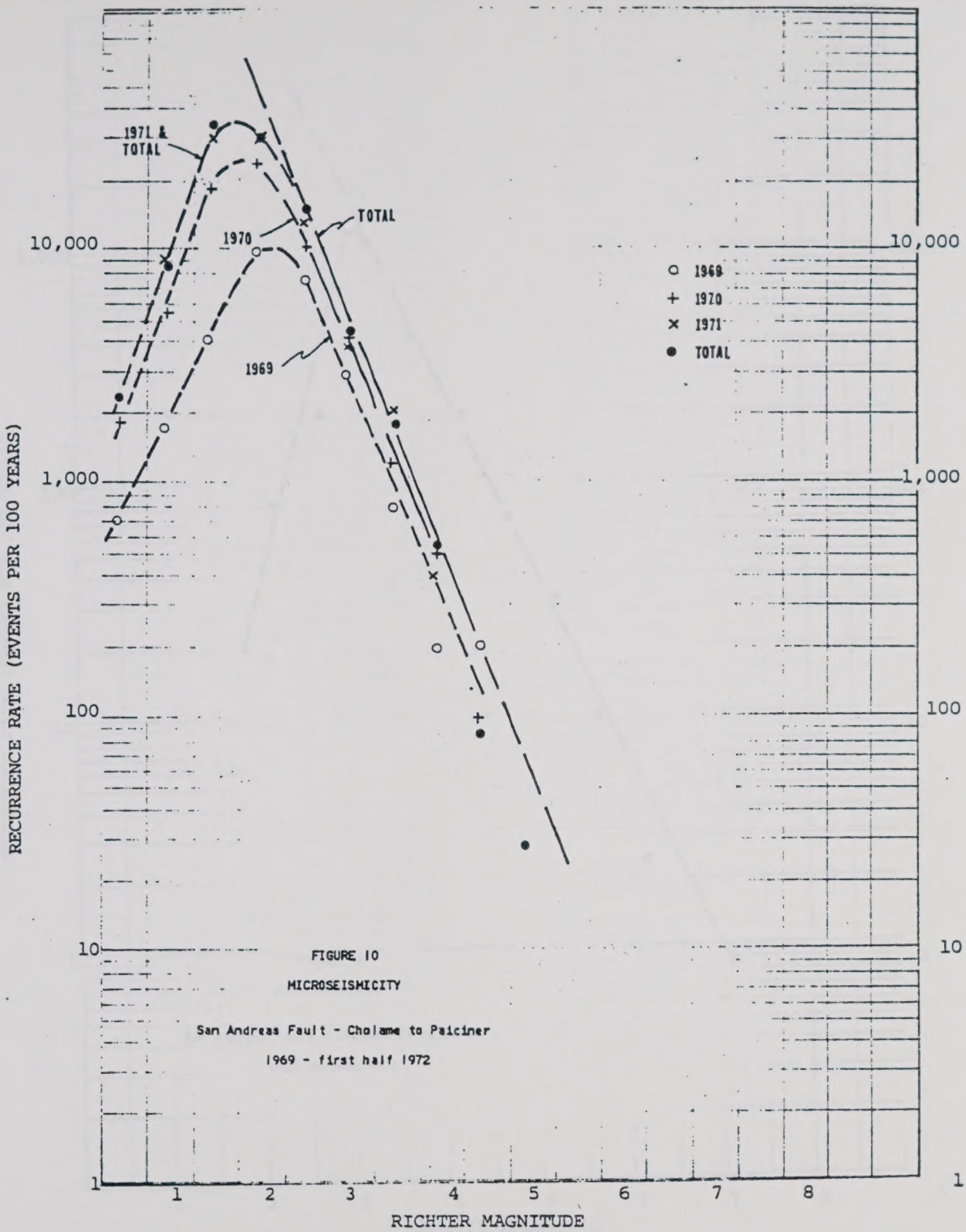


FIGURE 10

MICROSEISMICITY

San Andreas Fault - Cholame to Paicines

1969 - first half 1972

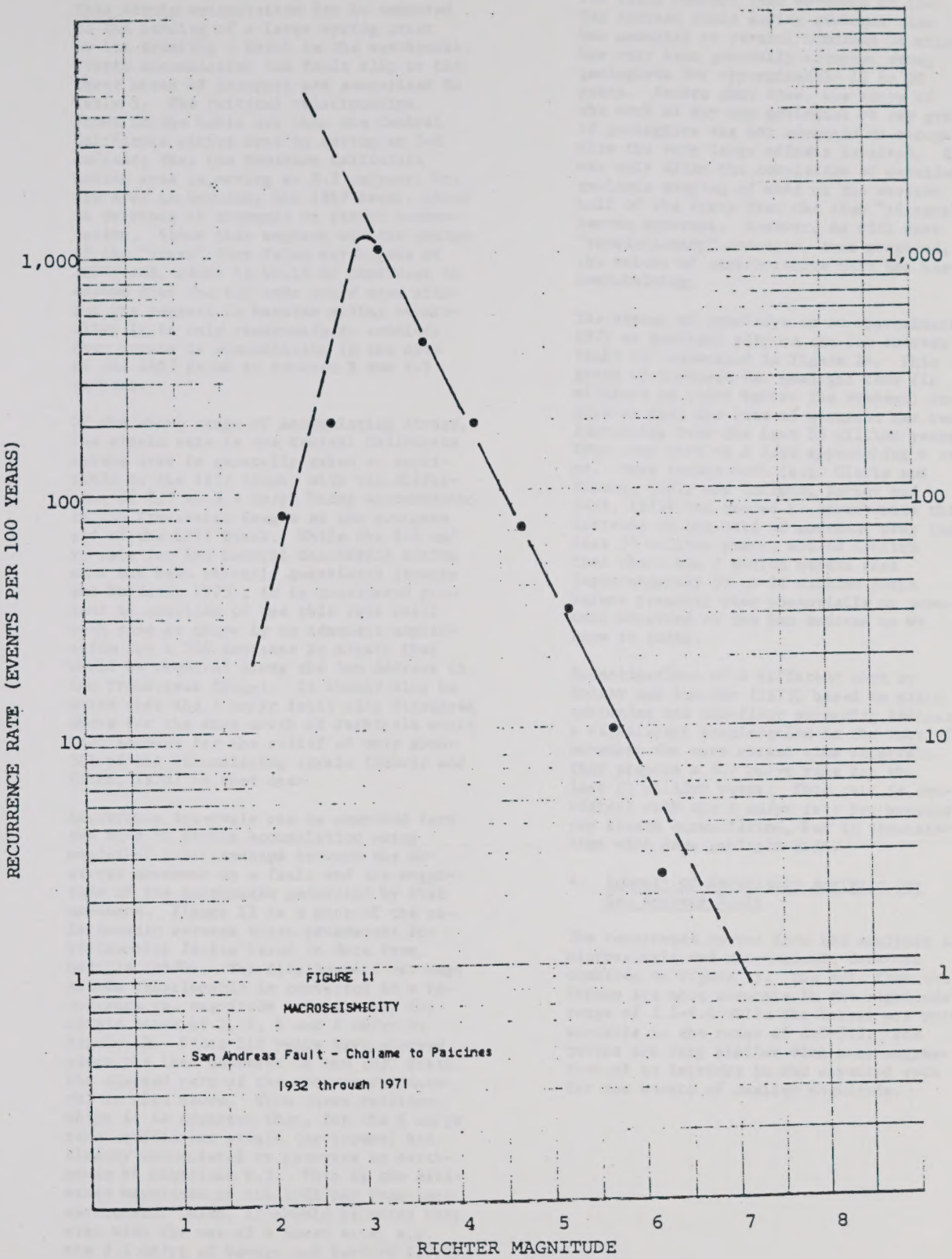


FIGURE 11

MACROSEISMICITY

San Andreas Fault - Cholame to Paicines

1932 through 1971

In addition to the actual slip along the fault, overall movement also includes the accumulation of strain in areas ranging up to tens of miles away from the fault. This strain accumulation can be compared to the bending of a large spring prior to its breaking - which is the earthquake. Strain accumulation and fault slip in the three areas of interest are summarized in Table 5. The critical relationships shown in the table are that the Central California active area is moving at 5-6 cm/year; that the Southern California active area is moving at 8.5 cm/year; but the area in between, the 1857 Break, shows no evidence of movement or strain accumulation. Since this segment was the source of the "great" Fort Tejon earthquake of 1857; and, since it would be imprudent to assume that the two ends could move without the segment in between moving eventually; it is only reasonable to conclude that stress is accumulating in the area of the 1857 Break at between 5 and 8.5 cm/year.

Of the above range of accumulating stress, the strain rate in the Central California active area is generally taken as applicable to the 1857 Break, with the difference of 2.5 to 3.5 cm/yr being accommodated in the Transverse Ranges at the southern end of the 1857 Break. While the 5-6 cm/yr rate for the Central California active area has been recently questioned (Savage and Burford, 1973), it is considered prudent to continue to use this rate until such time as there is an adequate explanation for a 70% decrease in strain that would be required along the San Andreas in the Transverse Ranges. It should also be noted that the 2 cm/yr fault slip discussed above for the area north of Parkfield would then account for the relief of only about 30% of the accumulating strain (Scholz and Fitch, 1970) in that area.

Recurrence intervals can be computed from the rate of strain accumulation using empirical relationships between the observed movement on a fault and the magnitude of the earthquake generated by that movement. Figure 12 is a plot of the relationship between these parameters for strike-slip faults based on data from Bonilla (1970). The displacement vs. magnitude relationship is converted to a recurrence vs. magnitude relationship for strain rates of 2, 4, 6 and 8 cm/yr in Figure 13. Since 116 years have elapsed since the last movement on the 1857 Break, the elapsed part of the recurrence interval is also shown. From these relationships it is apparent that, for the 6 cm/yr rate, sufficient strain (or stress) has already accumulated to generate an earthquake of magnitude 8.3. This is the estimated magnitude of the 1906 San Francisco earthquake. Also, it should be noted that even with the use of a lower rate, e.g. the 3.2 cm/yr of Savage and Burford (1973), a major earthquake (i.e. greater than magnitude 8.0) should be expected within the next 50 years on the segment of the San Andreas south of Cholame.

3. Geologic Slip

The basic concept that movement on the San Andreas fault during geologic time has amounted to several hundreds of miles has only been generally accepted among geologists for approximately 15 to 20 years. Before that time, the scope of the work of any one geologist or any group of geologists was not adequate to recognize the very large offsets involved. It was only after the completion of detailed geologic mapping of most of the western half of the State that the true "picture" became apparent. However, as with most "revolutionary" concepts, once proposed, the volume of corroborative data has been overwhelming.

The status of knowledge up to approximately 1972 on geologic slip on the San Andreas fault is summarized in Figure 14. This graph of movement vs. geologic time (in millions of years before the present) indicates that the rate of movement has been increasing over the last 25 million years from near zero to a rate approaching 6 cm/yr. More recent work (e.g. Clarke and Nilsen, 1973, and Huffman, Turner and Jack, 1973) has tended to corroborate this increase in the rate of movement over the last 25 million years, and to confirm that there was a period before that (approximately 50 to 25 million years before present) when essentially no movement occurred on the San Andreas as we know it today.

Investigations of a different sort by Molnar and Atwater (1973) based on plate tectonics and sea-floor spreading indicate a significant acceleration in the rate of movement for more recent time intervals. They propose a 5.7 cm/yr rate for the last 10 million years. This rate is consistent with the 6 cm/yr rate for present-day strain accumulation, but is inconsistent with some geologic data.

4. Summary of Recurrence Analysis for San Andreas Fault

The recurrence curves from the analysis of microseismic and macroseismic data are combined on Figure 15. The data from the former are more accurate in the magnitude range of 2.5-4.0 while the latter are more accurate in the range of 4.0-5.5. The curves are very similar with some suggestion of an increase in the expected rate for the events of smaller magnitude.

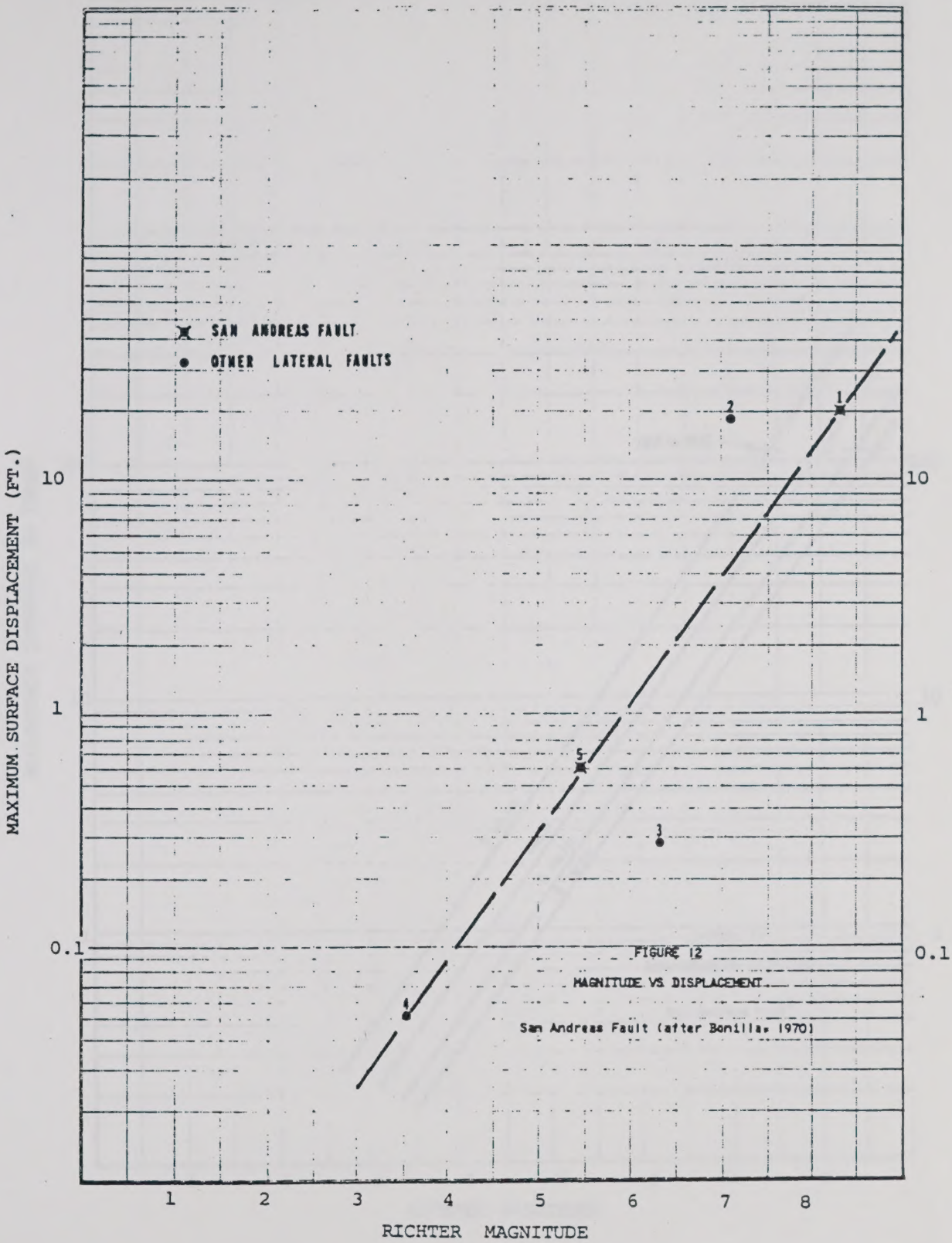


FIGURE 12

MAGNITUDE VS DISPLACEMENT

San Andreas Fault (after Bonilla, 1970)

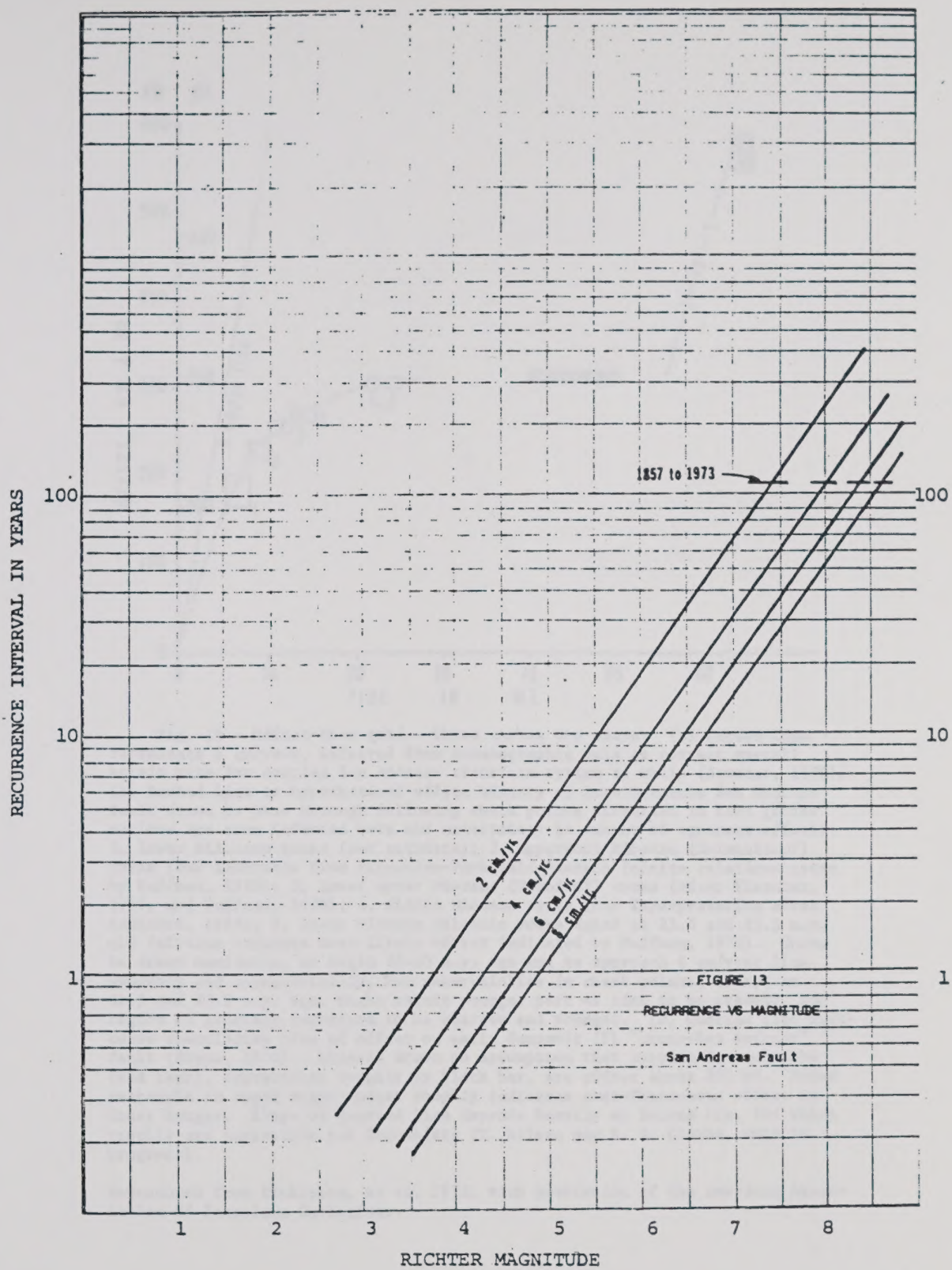


FIGURE 13

RECURRENCE VS MAGNITUDE

San Andreas Fault

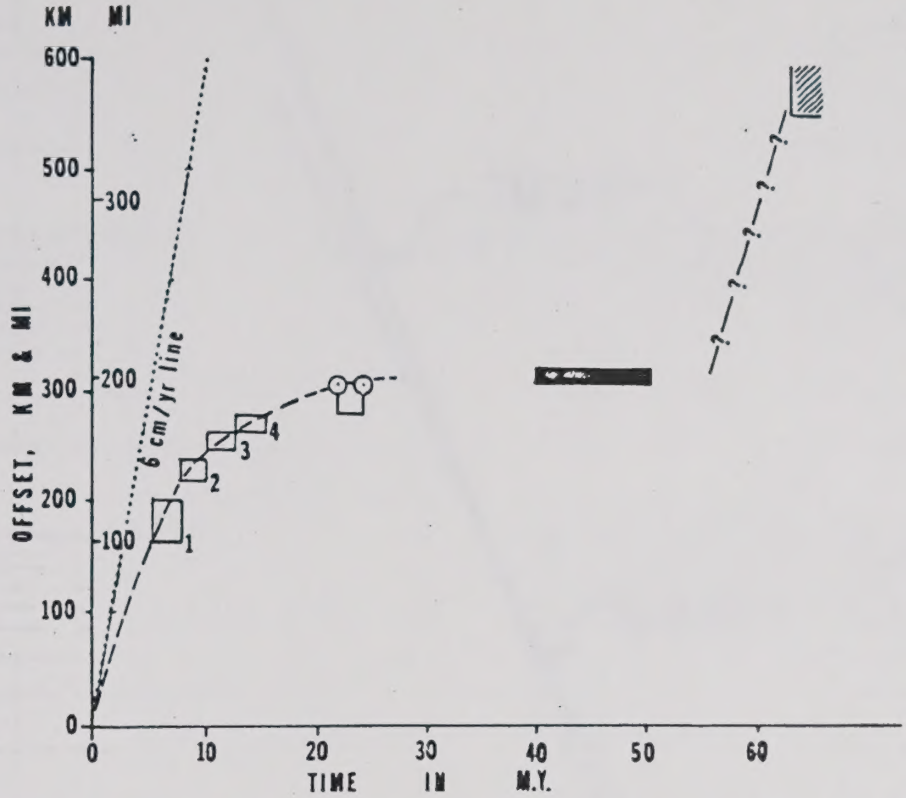


Fig. 14 - Offset-time grid. Three curves are shown: (a) Dotted line represents 6 cm/year, inferred from oceanographic data as current overall strain rate for complex San Andreas transform system as whole (Atwater, 1970). (b) Dashed line is hypothetical offset history of late Cenozoic San Andreas fault drawn to pass through following check points discussed in text (boxes enclose age span inferred here and uncertainty in amount of apparent offset): 1, lower Pliocene rocks (our estimate); 2, uppermost Miocene (Delmontian?) rocks (our inference from Pinnacles-Parkfield-Neenach felsite relations noted by Huffman, 1970); 3, lower upper Miocene (Mohnian?) rocks (after Fletcher, 1967, and Huffman, 1970); 4, middle Miocene rocks (our interpretation after Addicott, 1968); 5, lower Miocene volcanic rocks dated at 21.5 and 23.5 m.y. old (circles indicate most likely offset indicated by Huffman, 1970). Curve is drawn nominally, to begin 25-30 m.y. ago and to approach 6 cm/year line smoothly and asymptotically, but uncertainties in check points, except at 21.5 and 23.5 m.y. ago, might permit younger part of line to be steeper, and region of greatest curvature to be sharper and younger. (c) Queried line indicates speculative time of offset on early Cenozoic (?) "proto-San Andreas" fault (Suppe, 1970). Line is drawn on assumption that certain Eocene rocks (see text), represented roughly by black bar, are offset about 200 mi. Ruled rectangle in upper right corner roughly indicates post-Cretaceous offset in Coast Ranges. Slope of queried line depends heavily on Eocene tie, for which results are suggestive but incomplete (T. Nilsen and S. H. Clarke, work in progress).

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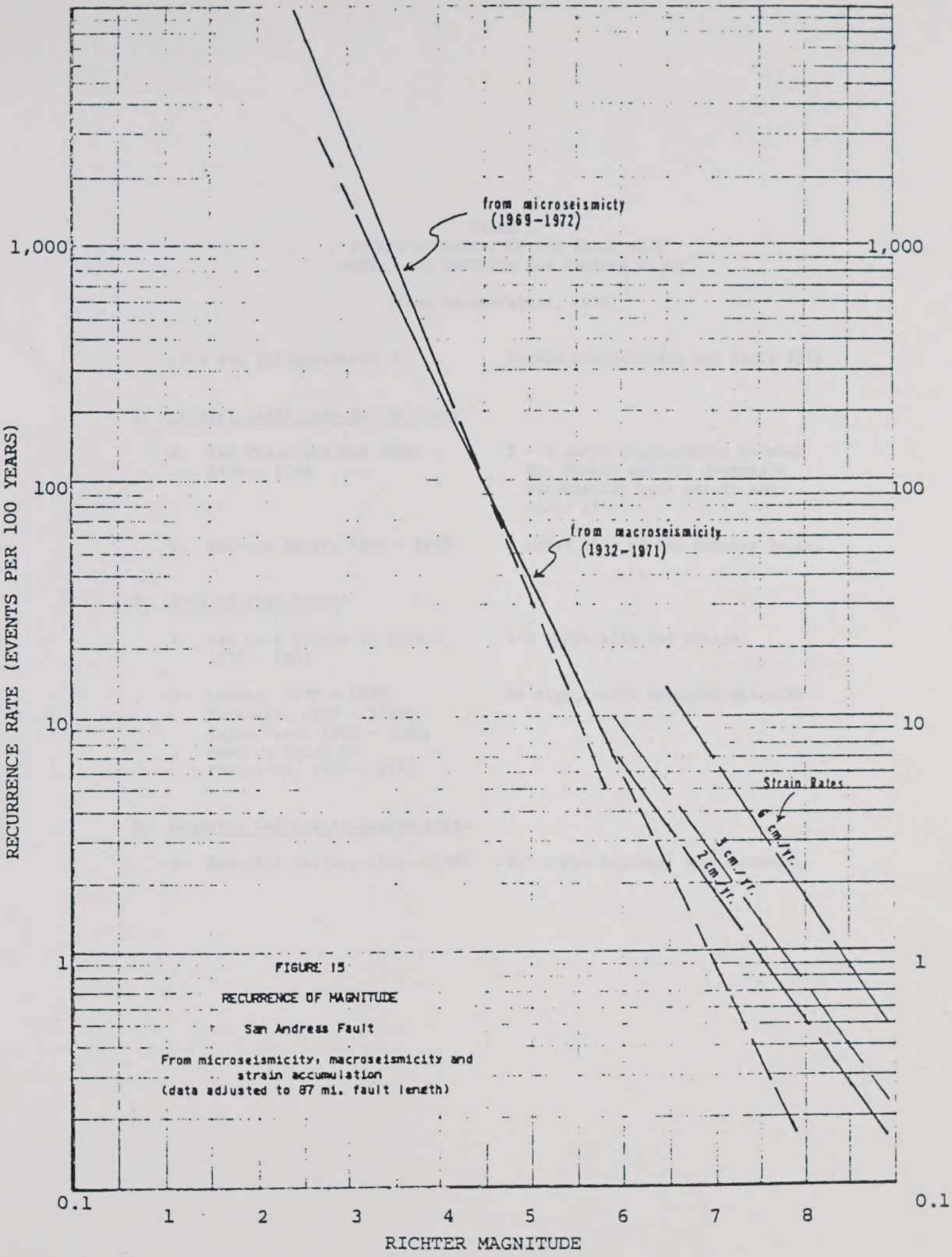


FIGURE 15

RECURRENCE OF MAGNITUDE

San Andreas Fault

From microseismicity, macroseismicity and strain accumulation
(data adjusted to 87 mi. fault length)

TABLE 5
STRAIN ACCUMULATION AND FAULT SLIP
CENTRAL AND SOUTHERN SAN ANDREAS FAULT

(From Greensfelder, 1972)

Area and Triangulation Net	Strain Accumulation and Fault Slip
1. Central California Active Area:	
a. San Francisco Bay Area, 1906 - 1969	5 - 6 cm/yr displacement between Mt. Diablo and San Francisco Penninsula; both strain and fault slip.
b. Salinas River, 1944 - 1963	3 cm/yr slip on San Andreas fault.
2. Area of 1857 Break:	
a. San Luis Obispo to Avenal, 1932 - 1951	1.5 cm/yr slip and strain.
b. Gorman, 1935 - 1956; Palmdale, 1938 - 1958; Cajon Pass, 1949 - 1963; Newport Beach to Riverside, 1929 - 1953	No significant movement detected.
3. Southern California Active Area:	
a. Imperial Valley, 1941 - 1967	8.5 cm/yr regional displacement.

The inclusion on the graph of the rate derived from strain accumulation requires additional explanation. As was noted previously, the rates derived from seismicity apply to an 87 mile segment of the fault. If a larger segment having the same level of activity had been used, the rates would have been higher. Since the larger earthquakes normally involve rupture surfaces larger than 87 miles, rates must be corrected to the 87-mile length if they are to be compared to the seismicity data. This correction is based on empirical relationships developed by Bonilla (1970), listed in Table 6 and plotted on Figure 16. Using these relationships, strike-slip movement accompanying a magnitude 8.3 earthquake on the San Andreas fault would be expected to occur along a length of approximately 200 miles. Correction of the recurrence rates discussed previously for a "great" earthquake (M=8.3) are as follows:

Strain Rate (cm/yr)	True Recurrence Rate (Events/ 100 yrs)	Effective Recurrence Rate for 87-mile Segment (Events/ 100 yrs)
6	0.985	0.428
3	0.492	0.214
2	0.326	0.143

Similar corrections for a "large" earthquake (M=7.0) with a surface rupture of 68 miles (Figure 16) are as follows:

Strain Rate (cm/yr)	True Recurrence Rate (Events/ 100 yrs)	Effective Recurrence Rate for 87-mile Segment (Events/ 100 yrs)
6	5.19	6.64
3	2.59	3.32
2	1.73	2.21

The effective recurrence rates computed above are plotted on Figure 15 for comparison with the rates developed from the seismicity of the active segment of the fault. These data and the relationships discussed in the previous sections indicate the following with regard to the recurrence rates for a major, damaging earthquake on the San Andreas fault:

1. Extrapolation of the curve developed from macroseismic data yields recurrence rates that are less than that from a strain rate of only 2 cm/yr.

2. Extrapolation of the curve developed from microseismic data yields recurrence rates that are even less than those from the macroseismic data.

3. Since the minimum strain rate appears to be approximately 3.2 cm/yr and a more prudent choice would be the 6 cm/yr rate, the latter is recommended as the rate on which to base the risk of a major earthquake on the 1857 Break of the San Andreas fault.

4. At 6 cm/yr, the recurrence interval for a magnitude 8.3 earthquake is only slightly in excess of 100 years. Since 116 years have elapsed since the last "great" earthquake or this segment, a major earthquake can be considered as imminent.

5. Even at the smaller strain rate of 3 cm/yr, a major earthquake (M=8.3-8.5) should be expected sometime in the next 100 to 150 years.

6. The variation in recurrence rates for major earthquakes as developed from the three data sources suggests an increase in the efficiency of energy release for major earthquakes, as opposed to the small and intermediate sized earthquakes that characterize the active areas.

c. Owens Valley Fault Group

1. Seismicity

Earthquake epicenters for the Owens Valley fault group for the period 1932 through 1971 are shown on Plate I. They show a concentration in the general area of the Valley and also in the area of volcanic activity between Bishop and Mono Lake. A potentially important characteristic of the areal pattern of the epicenters in the relatively small number of events in the area between Bishop and Owens Lake. This is the area of fault rupture during the "great" Owens Valley earthquake of 1872, and the lack of recent epicenters can be attributed to the release of the accumulated strain in that year. An important corollary of this observation is that the "quiet zone" is not limited to the area of the fault rupture, but extends to the northeast and southwest across the trend of activity. This suggests that although the epicenters in this area are scattered over a wide area, they are related to the zone of active faulting along the east side of the Sierra Nevada.

Because of these differences in the level of activity, the Owens Valley fault zone is divided into three areas: a "north area" that includes the earthquake activity near Bishop and to the north; a "central area" that is seismically quiet; and a "south area" that includes the area of the study south of the "quiet" zone. In addition to this subdivision, the overall trend has been divided into a near zone that includes the highest concentration of events, and wide zone that includes essentially all the events that appear to be related to the faulting on the east side of the Sierra Nevada. The limit of the near zone

TABLE 6

Faults Used in Constructing Figure 16.

No.	Fault	Year	Magnitude	Length (Mi.)
1	San Andreas	1906	8.3	270
2	Imperial	1940	7.1(6.5±)	40+
3	Manix	1947	6.4	1
4	Superstition	1951	5.6	2
5	Fairweather	1958	8.0	115-124
6	Imperial	1966	3.6	6
7	San Andreas	1966	5.5	23
8	Owens Valley	1872	8.3±	60±
9	Pleasant Valley	1915	7.6	20-40
10	Cedar Mountain	1932	7.3	38
11	Excelsior Mtns.	1934	6.5	0.9
12	Fort Sage	1950 (July)	5.6	5.5
13	Rainbow Mountain	1954 (August)	6.6	11
14	Rainbow Mountain	1954	6.8	19
15	Fairview Peak	1954	7.1	36
16	Dixie Valley	1954	6.8	38
17	San Miguel, Mex.	1956	6.8	12+
18	Hebgen Lake	1959	7.1	15

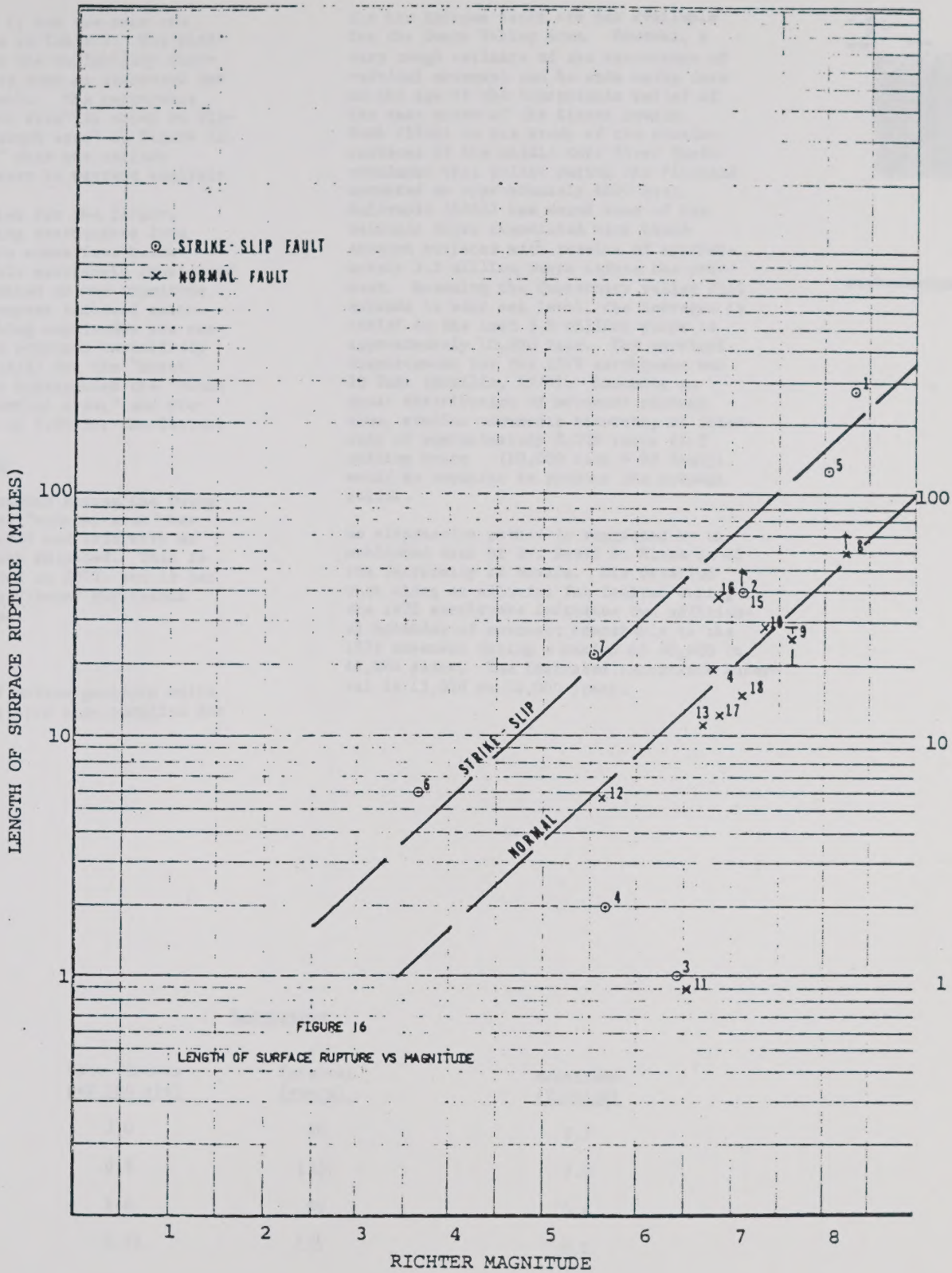


FIGURE 16

LENGTH OF SURFACE RUPTURE VS MAGNITUDE

on Plate I, and the data are zone in Table 7. The plot- e and the reliability char- ıtics are the same as discussed for ı Andreas fault. The recurrence ır the "north area" is shown on Fig- , and the "south area" on Figure 18. ıntral area" does not include .ent epicenters to warrent analysis.

:urrence rates for the larger, .ally damaging earthquakes from :wo areas are summarized below. ɛimum probable earthquake considered ltrarily limited to one magnitude ıbove the largest recorded earth- The resulting magnitudes are con- ɛ with those proposed tentatively ensfelder (1973) for the "north he does not distinguish the "south from the "central area," and pro- ı magnitude of 8.25 for the latter.

ustal Strain

ngulation network across the Owens fault in the "central area" has urveyed in 1935 and 1956 with no icant movement detected. This is ult that moved in 1872, and it has ntly not experienced any recent adjustment.

ɔlo, Slip

n offsets of unique geologic units s those that have been compiled for the San Andreas fault are not available for the Owens Valley area. However, a very rough estimate of the recurrence of vertical movement can be made using data on the age of the topographic relief of the east slope of the Sierra Nevada. Webb (1946) in his study of the erosion surfaces of the middle Kern River Basin concluded that relief during the Pliocene amounted to approximately 4000 feet. Dalrymple (1963) has dated some of the volcanic flows associated with these erosion surfaces with results of approximately 3.5 million years before the present. Assuming the Quaternary valley fill extends to near sea level, the increase in relief in the last 3.5 million years is approximately 10,000 feet. The vertical displacement for the 1872 earthquake was 23 feet (Bonilla, 1970). Assuming an equal distribution of movement through time, similar movements occurring at intervals of approximately 8,000 years (3.5 million years [10,000 feet ÷ 23 feet]) would be required to produce the present relief.

An alternative method is suggested by unpublished data of Dr. David B. Slemmons of the University of Nevada. His detailed work along an alluvial fan faulted during the 1872 earthquake indicates two additional episodes of movement comparable to the 1872 movement during a period of 40,000 to 60,000 years. The indicated recurrence interval is 13,000 to 20,000 years.

Recurrence

rea	Rate (Events per 100 yrs)	Interval (years)	Magnitude (Richter)
ɔrth	2.0	50	6.5
	0.8	125	7.0
ɔuth	2.0	50	5.6
	0.75	135	6.0

TABLE 7
MACROSEISMICITY OF THE OWENS VALLEY FAULT ZONE
1932 through 1971

Number of Events

	"North Area"				"South Area"				TOTAL			
	Near Zone		Wide Zone		Near Zone		Wide Zone		Near Zone		Wide Zone	
Magnitude	40yrs.	100yrs.	40yrs.	100yrs.	40yrs.	100yrs.	40yrs.	100yrs.	40yrs.	100yrs.	40yrs.	100yrs.
1.0-1.4	--	--	--	--	1	2.5	1	2.5	1	2.5	1	2.5
1.5-1.9	--	--	--	--	8	20.0	8	20.0	8	20.0	8	20.0
2.0-2.4	2	5.0	3	7.5	22	55.0	24	60.0	24	60.0	27	67.5
2.5-2.9	7	17.5	13	32.5	34	85.0	39	97.5	41	102.5	52	130.0
3.0-3.4	115	287.5	152	380.0	92	230.0	125	312.5	207	517.5	277	692.5
3.5-3.9	78	195.0	120	300.0	59	147.5	72	180.0	137	342.5	192	480.0
4.0-4.4	69	172.5	105	262.5	19	47.5	24	60.0	88	220.0	129	322.5
4.5-4.9	18	45.0	31	77.5	3	7.5	4	10.0	21	52.5	35	87.5
5.0-5.4	5	12.5	7	17.5	2	5.0	2	5.0	7	17.5	9	22.5
5.5-5.9	2	5.0	3	7.5	--	--	--	--	2	5.0	3	7.5
6.0-6.4	2	5.0	2	5.0	--	--	--	--	2	5.0	2	5.0

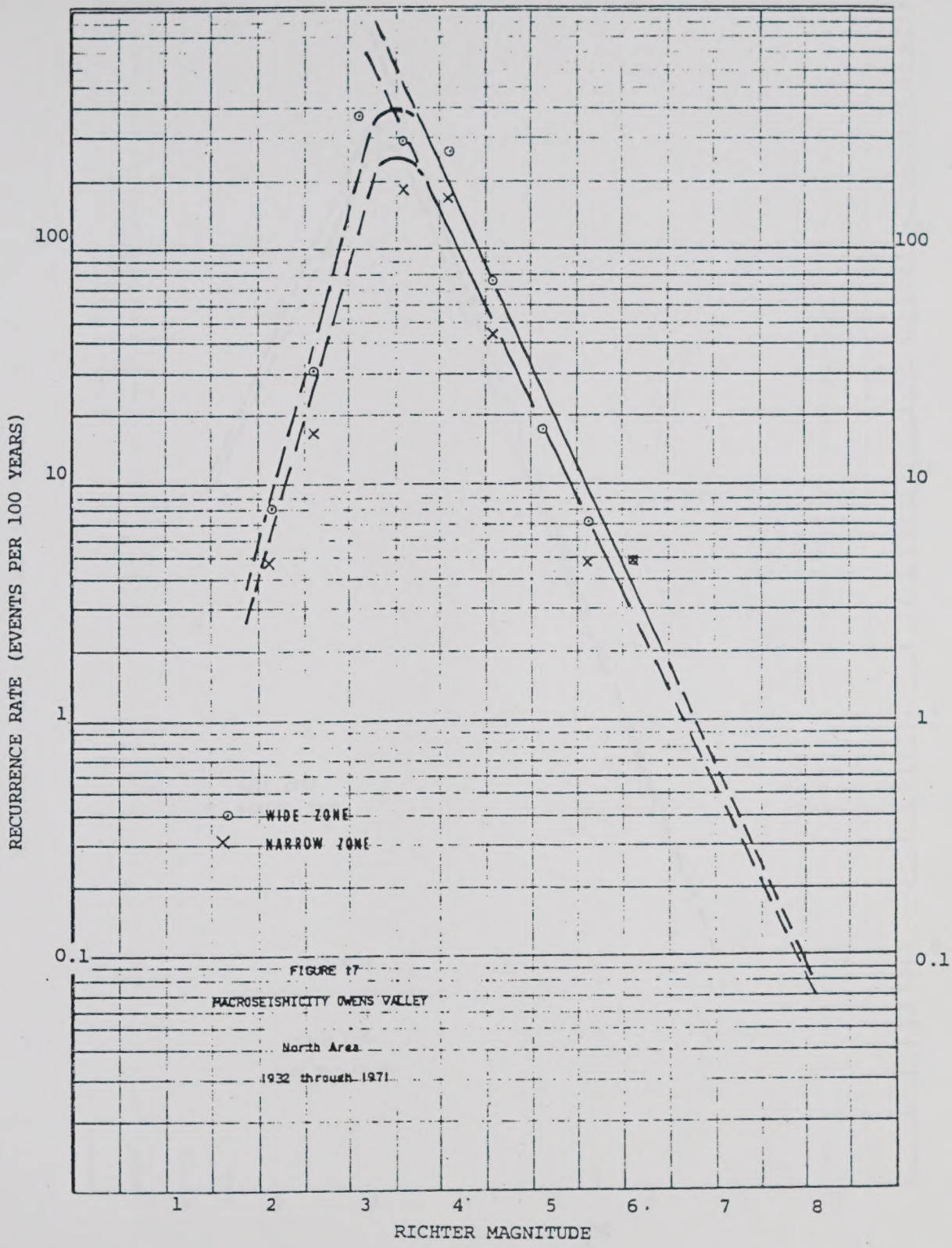


FIGURE 17

MACROSEISMICITY OWENS VALLEY

North Area

1932 through 1971

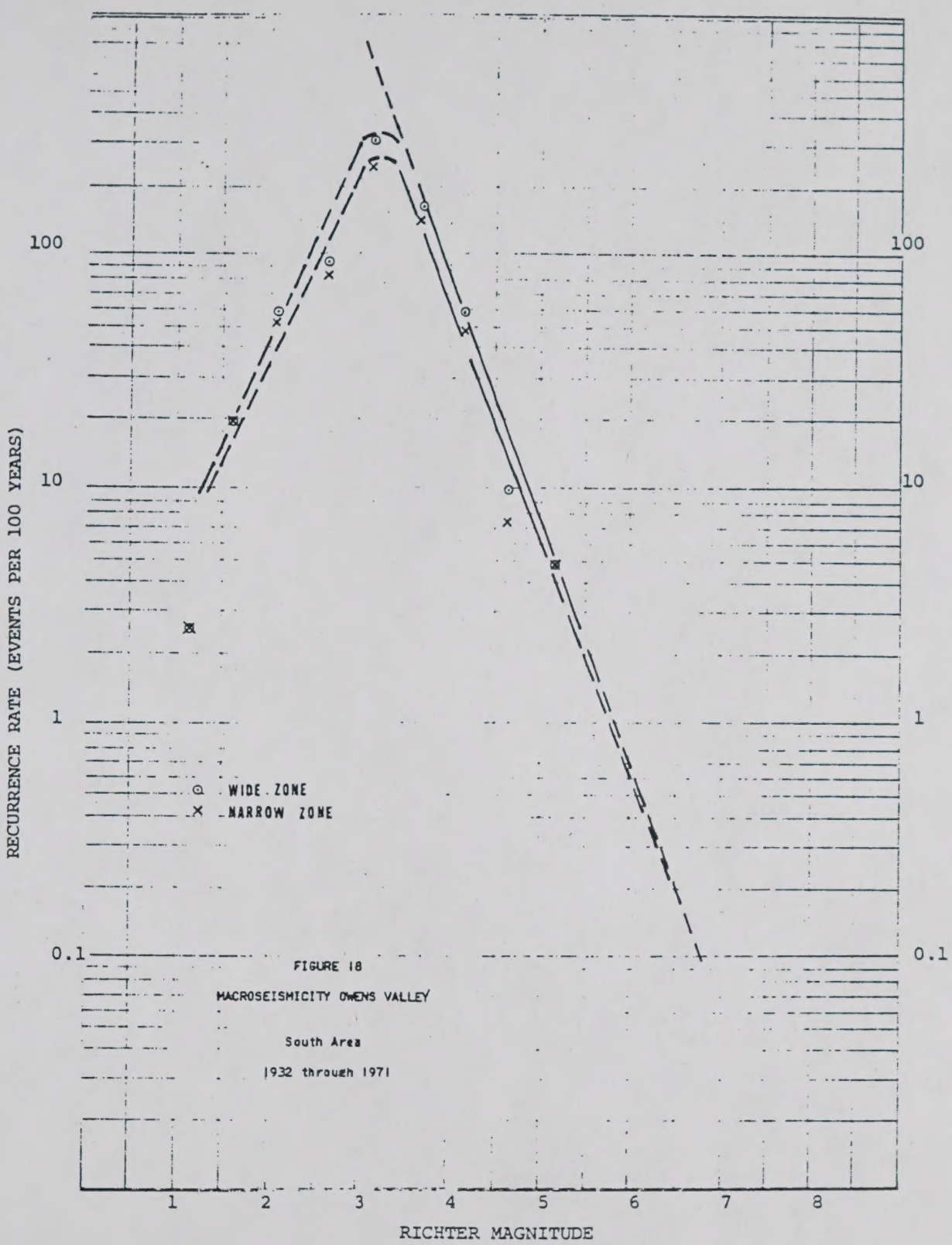


FIGURE 18

MACROSEISMICITY OWENS VALLEY

South Area

1932 through 1971

4. Summary of Recurrence Analysis for Owens Valley Fault Group

Recurrence rates can be established for the more active "north area" and "south area" using epicenter data. The "central area," however, appears to be similar to the 1857 Break on the San Andreas fault in that it is quiet seismically but has been the source of one of California's three "great" earthquakes during historic time. The problem is not will it move again; we must assume it will. The problem is to determine a credible level of risk to aid in determining the appropriate action.

The data are not adequate for a direct solution of this problem, but what is available suggests an analogy to the San Andreas fault. If the results of the analysis of the several types of data for the San Andreas are applied to the Owens Valley fault, the recurrence rate for the "central area," should be at least as large, and probably larger than the adjacent active areas. Applying this logic, recurrence rates for the maximum probable earthquake of magnitude 8.25 (Greensfelder, 1973) should be at least in the range of 0.065 (Figure 17) to less than 0.01 (Figure 18) events per 100 years (i.e. recurrence interval of 1500 to more than 10,000 years). While consideration of the geologic slip rate would tend to favor the larger recurrence interval, the increased efficiency of energy release that is suggested for the San Andreas fault would favor a shorter recurrence interval. A direct relationship between the two faults should not be expected because the mechanical characteristics of the two faults are quite different. However, since the seismicity of the active areas are both less than those of the San Andreas fault, the recurrence intervals are probably longer. On this basis, the recurrence interval for the expected magnitude 8.25 earthquake is estimated at somewhere in the range of 300 to 10,000 years. It should be emphasized that this range is strictly a "ball park" estimate. The data are not adequate for a more accurate determination.

d. White Wolf Fault

The White wolf fault was essentially unknown as an active fault until the 1952 earthquakes in Kern County. The investigations that followed showed clearly that had the fault been investigated for potential activity, there would have been, at a minimum, a much greater level of concern. The problem was that there was no obvious sign of activity. Seismicity was low befor the earthquake and its many aftershocks, and there were no known creep or small movements on the fault in the years prior to the earthquake. Thus, the seismicity of the area is limited to a single event and its aftershocks, and is not adequate for recurrence analysis. Left-lateral creep of 1.3 cm/yr is now reported along the fault (California Division of Mines and Geology, 1972), but this can be considered an after effect of the 1952 earthquake sequence.

Geologic slip has been used by Lamar, Merifield & Proctor to estimate the recurrence interval for a magnitude 7.0 earthquake of approximately 1,000 - 5,000 years. While experience with the San Andreas fault suggests that geologic slip rates, averaged over several millions of years, may be less than rates occurring today, there is little other data with which to refine the estimate.

e. Summary of Recurrence Analysis

The objective of the recurrence analysis for the known active faults that could generate damaging earthquakes in the Five-County area has been to establish, as accurately as possible, the average time intervals that should be expected between major earthquakes. Where possible, several methods have been discussed. These have been included not only to serve as rough checks on the most reliable method, but also to emphasize the wide range of values that can be obtained depending on the information that is available.

The recurrence rates or intervals developed in the preceding sections are intended to describe seismic risk. As discussed in the Introduction, the recurrence of earthquakes can be used to describe the risk of an earthquake occurring in much the same manner that the recurrence of floods is used to describe the risk of a flood occurring. In this context, the magnitude of the "100-year earthquake" or the "300-year earthquake" can be obtained directly from the recurrence plots in the preceding sections.

Values obtained in this manner, however, can be very misleading. We have seen in the previous sections that individual segments of the major faults are relieving the accumulating strain in different ways. The active segments are relieving this strain as many small-to-moderate magnitude earthquakes. These segments are less likely to be the source of a "great" earthquake. In the same context, the seismically "quiet" segments appear to be storing energy, which most likely will be released, as it has in the past, as a "great" earthquake. These relationships cannot be said to be proven in the scientific sense; the seismic record is too short to be absolutely sure. They are, however, logical relationships that suggest the magnitude of the "maximum probable" earthquake that should be expected from a particular fault segment in the future.

The maximum probable earthquake and its recurrence rate and recurrence interval are summarized in Table 8 for each of the major fault segments discussed in the previous sections. The choice of the maximum probable magnitude is based on the concepts discussed above, and the recurrence is based on the data developed in the previous sections. If the year of the last occurrence of the maximum probable earthquake is known for a particular segment, the time remaining in the recurrence interval is also shown. It is emphasized that the inclusion of this last item is not meant to imply the prediction of an earthquake in a particular year; and is included only to remind the reader that a substantial part of some recurrence intervals have elapsed.

3. Intensity of Recorded Earthquakes

a. General Statement

A general description of some of the more important earthquakes that have resulted in strong shaking in the Five-County area are included to: 1) document the levels of shaking that have occurred in the past and which should be expected in the future; and, 2) to investigate local variations in shaking that can be used as a "rough check" of the microzonation that will be developed by an independent method. For this reason, isoseismal maps have been constructed for each of the more important earthquakes for which data are available. These maps show the areal variation in the intensity of earthquake shaking as described by the standard intensity scales described in the Introduction. All the maps are based on the Modified Mercalli Scale of 1931 except the San Francisco earthquake of 1906, which is based on the Rossi-Forel scale that was in use at that time. The equivalent Rossi-Forel levels are given in the description of the Modified Mercalli Scale in the Introduction.

b. San Francisco Earthquake of 1906

The San Francisco earthquake of 1906 is undoubtedly the most important earthquake to have affected the Five-County area during historic time. It was investigated in great detail by geologists, seismologists, and engineers of the State Earthquake Investigation Commission, and the results of this investigation have served as the basis for much of our understanding of the relationship between earthquakes and faulting. The importance of this earthquake to our understanding of future earthquakes in the Five-County area is that it is the only "look-alike" for the "great" earthquake that is expected along the 1857 Break of the San Andreas fault. Had the 1857 quake itself been studied in the detail that was given to the 1906 event, it would have been the most important event. However, very little is known about this earthquake that is useful for the objectives stated above.

The 1906 earthquake occurred as the result of rupture along the San Andreas fault from Cape Mendocino to near Hollister (Figures 7 and 8). Intensities of shaking as mapped by Lawson, et al (1908, Plate 23) for the State, and included here for the Five-County area and vicinity as Figure 19, show the following variations significant to our understanding of shaking to be expected in the Five-County area:

1. Shaking reached a maximum of intensity X (Rossi-Forel) near the zone of fault rupture and generally decreased with increasing distance from the fault.

2. Local variation from the overall decrease with distance can be generalized as a decrease in areas underlain by firm bedrock and an increase in areas underlain by alluvium.

3. Examples of increased shaking in the alluvial valleys in or near the Five-County area are (Figure 19) the Salinas Valley, Priest Valley, and the west-central San Joaquin Valley between Los Banos and Coalinga.

4. The latter is the most prominent local anomaly in the State, with Intensity IX at Los Banos and VIII to IX in the Coalinga area more than 80 miles from the nearest point on the fault rupture. This is in striking contrast to intensities as low as V on firmer ground in the Santa Cruz area about 15 miles from the fault break.

5. The high intensities on the west side of the Valley give way rapidly to a broad zone of Intensity VI - VII and a narrower zone of Intensity V - VI near the foothills of the Sierra Nevada.

6. Intensities in most of the Five-County part of the Sierras were a near constant IV - V.

A similar pattern of shaking should occur during the expected magnitude 8.3 - 8.5 earthquake on the 1857 Break of the San Andreas fault, except that intensities will probably be higher in the south because of the proximity of the 1857 Break to that part of the Five-County area.

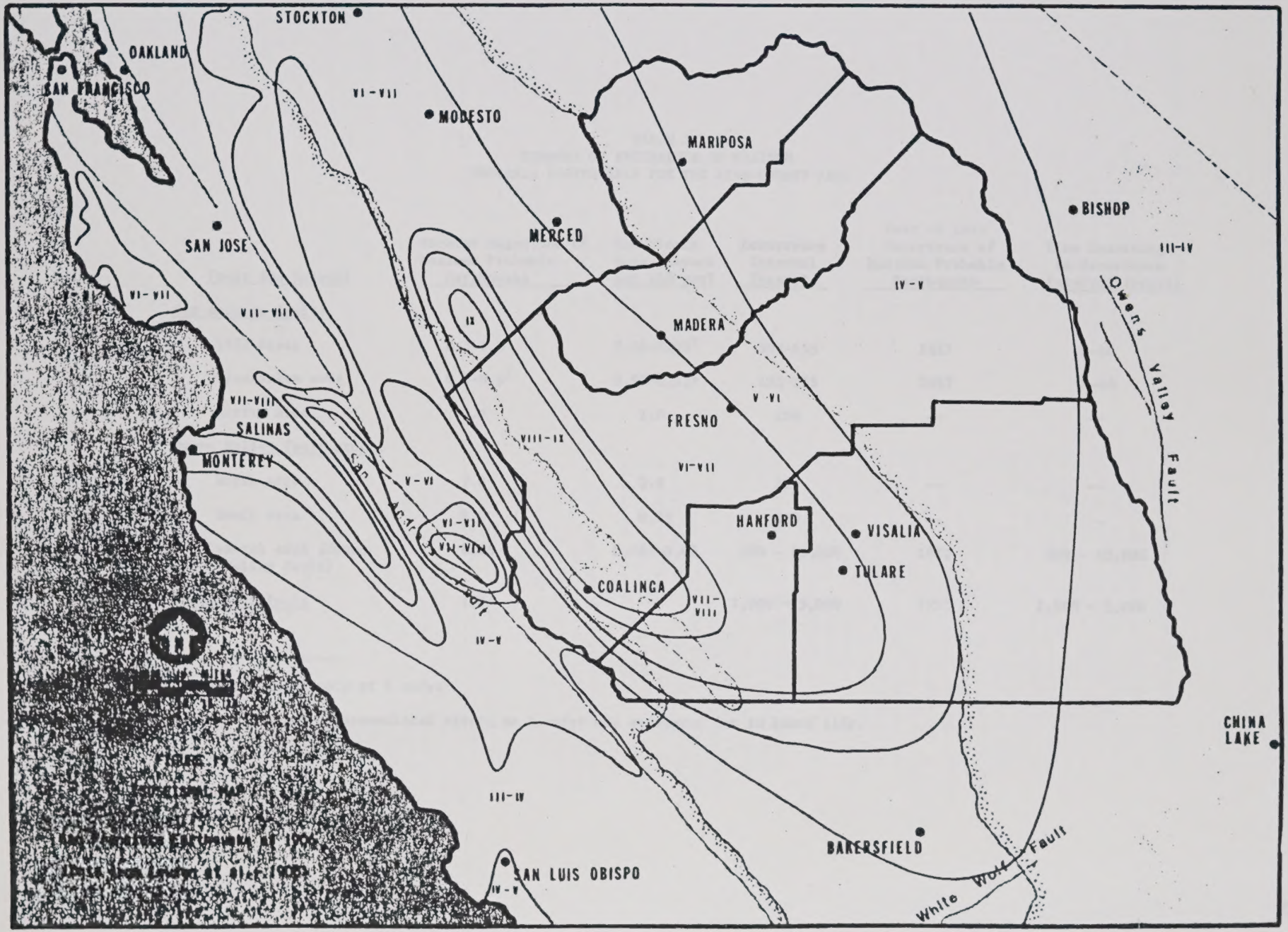


FIGURE 19

MERCALLI MAP

SAN FRANCISCO EARTHQUAKE OF 1906

(DATA FROM LAWSON ET ALIA, 1908)

TABLE 8
SUMMARY OF RECURRENCE OF MAXIMUM
PROBABLE EARTHQUAKES FOR THE FIVE-COUNTY AREA

Fault and Segment	Richter Magnitude of Maximum Probable Earthquake	Recurrence Rate (Events per 100 yrs)	Recurrence Interval (years)	Year of Last Occurrence of Maximum Probable Earthquake	Time Remaining in Recurrence Interval (years)
San Andreas fault:					
1857 Break	8.3-8.5	0.98-0.65[1]	102-155	1857	0-40
Transition zone	8.1-8.3[2]	0.98-0.65[1]	102-155	1857	0-40
Active area	7.0	1.0	100	--	--
Owens Valley fault group:					
North area	7.0	0.8	125	--	--
South area	6.0	0.75	135	--	--
Central area (Owens Valley fault)	8.25	0.065-0.01	300 - 10,000	1872	200 - 10,000
White Wolf fault	7.0	--	1,000 - 5,000	1952	1,000 - 5,000

[1]Based on strain rate of 6 cm/yr.

[2]Assumes release of accumulated strain at 4 cm/yr not accounted for in known slip.

c. Recent Earthquakes on the San Andreas Fault

Isoseismal maps (Figures 20-22) have been prepared from data in United States Earthquakes for the three largest earthquakes that have occurred on the San Andreas fault since 1928 when the compilation of detailed records was begun in the area. These maps generally confirm the observations of local variation as noted previously for the 1906 earthquake. As with most earthquakes of this magnitude (5.5 - 6.0), intense shaking (greater than VII to VIII) is limited to a relatively small area near the epicenter, with only moderate to barely perceptible shaking in most of the Five-County area. Earthquakes of this magnitude should be expected from the transition zone of the San Andreas fault at intervals averaging approximately 10 years (Figure 15).

d. Owens Valley Earthquake of 1872

The Owens Valley earthquake of 1872 is one of the three "great" earthquakes of California recorded history. The magnitude has been estimated at between 8.0 and 8.3 with the larger being the more likely (Oakshott, Greensfelder and Kahle, 1972). Ground rupture (Plate I) extended from south of Owens Lake to near Bishop (California Geology, 1972). Records of the intensity were not kept at that time, but an isoseismal map (Figure 23) has been compiled by Greensfelder (Oakshott, Greensfelder and Kahle, 1972) from newspaper accounts. This map indicates intensities (Modified Mercalli) of VII-VIII on the east side of the San Joaquin Valley near the foothills, and intensities as high as VIII in the mountain valleys of the Sierra Nevada.

e. Recent Earthquakes on the Owens Valley Fault Group

Isoseismal maps (Figures 24 and 25) have been prepared from data in United States Earthquakes for the two largest earthquakes that have occurred in the Owens Valley area since the compilation of detailed records was begun in 1928. These maps do not show the high intensities in the epicentral area as was noted for the San Andreas earthquakes of the same magnitude (5.5-6.0). This can be attributed to a greater focal depth and possibly also to a more disbursed population in the area. Higher intensities in the Five-County area are limited to some valleys in the Sierras and to some east-valley locations at or near Fresno and in south-central Tulare County. The decrease in intensity through the dominantly granitic bedrock of the Sierra Nevada is apparently low, and intensities in the east Valley are not significantly lower than those in the Owens Valley much nearer the epicenter.

f. Arvin-Tehachapi Earthquake of 1952

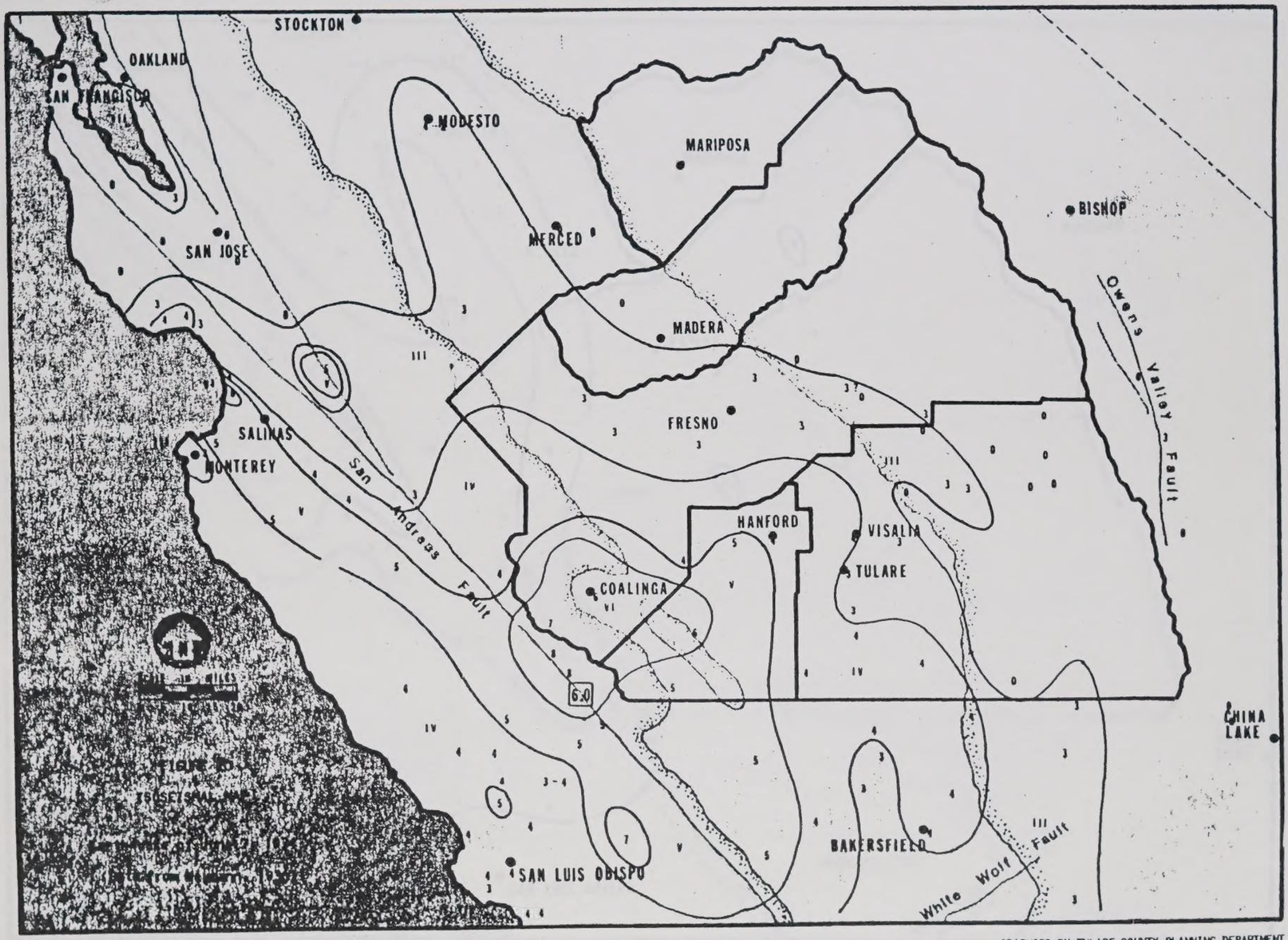
The Arvin-Tehachapi earthquake of July 21, 1952 occurred as the result of movement on the White Wolf fault located south of Bakersfield. This fault is not as important as the source of major earthquakes or are the San Andreas and Owens Valley faults, but this particular earthquake is one of the most severe in the area for which detailed intensity data are available. This data is particularly significant in that the source of the shaking is to the south of the Five-County area, and is oriented in such a way that, other conditions being equal, intensities along lines oriented northeast-southwest should be equal. Thus, variations in observed intensities in this direction should be a good indication of the variations in local conditions that will influence the microzonation of the area.

The intensity data for this earthquake are shown on two maps; the generalized distribution is shown on the published map by the Coast and Geodetic Survey (Neumann and Cloud, 1955) reproduced here as Figure 26, and the detail in the Five-County area from United States Earthquakes is shown on Figure 27. Variations in observed intensity pertinent to the Five-County area are as follows:

1. The Coalinga area is high in comparison to the bedrock areas to the west and slightly lower than the alluvial areas of western San Joaquin Valley to the east.

2. The extreme southwestern side of the Valley experienced higher intensities, relatively, than the east side of the valley, except in western Kings County. The trend of higher intensities in northwestern Kern County gives way to the northwest to lower intensities in the Tulare Lake area.

3. Intensities in the Sierra Nevada are comparable to those in the Valley, and are locally high in some mountain valleys such as Yosemite.



GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

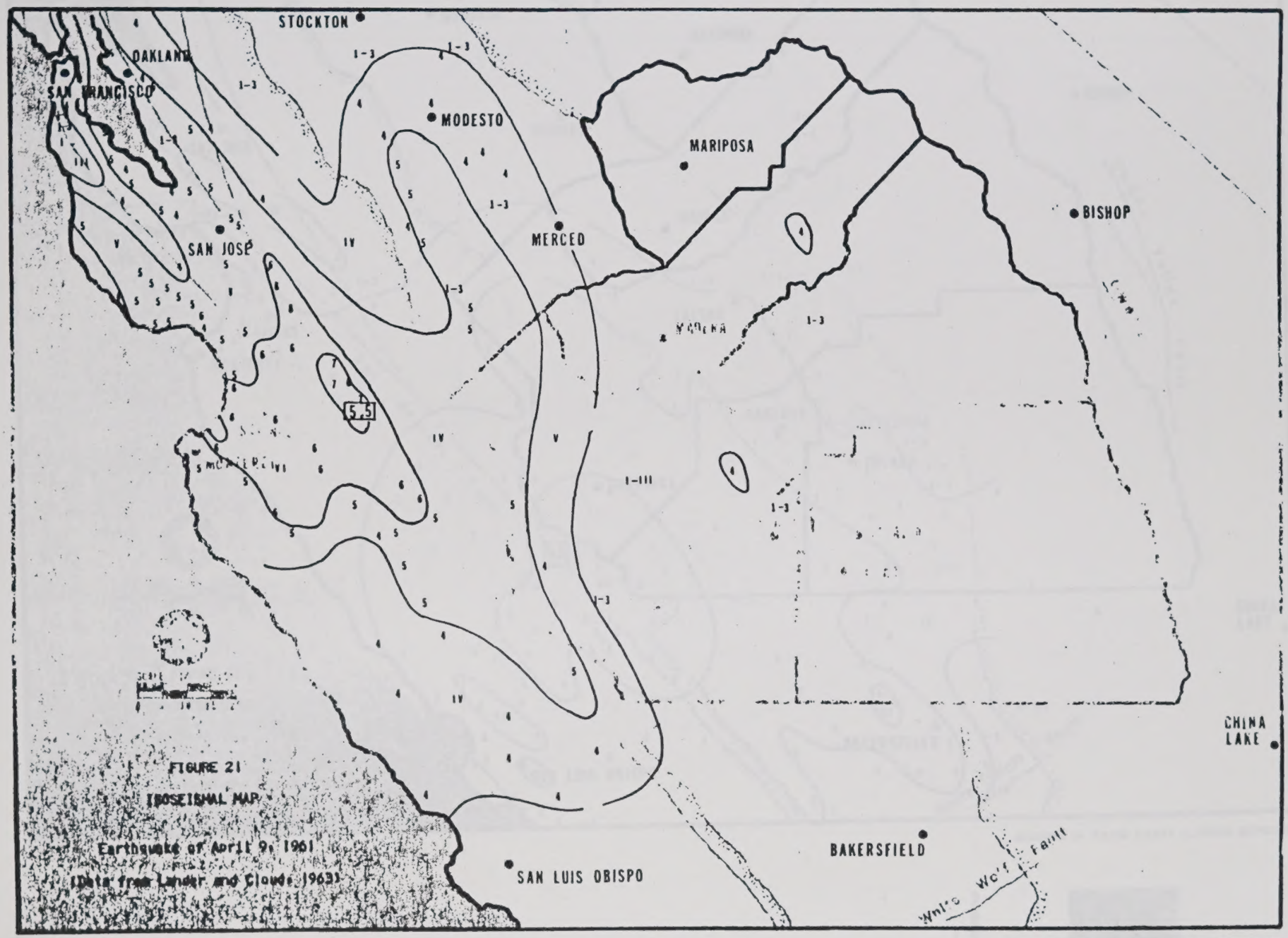


FIGURE 21

ISOSEISMAL MAP

Earthquake of April 9, 1961

(Data from Lander and Cloude 1963)

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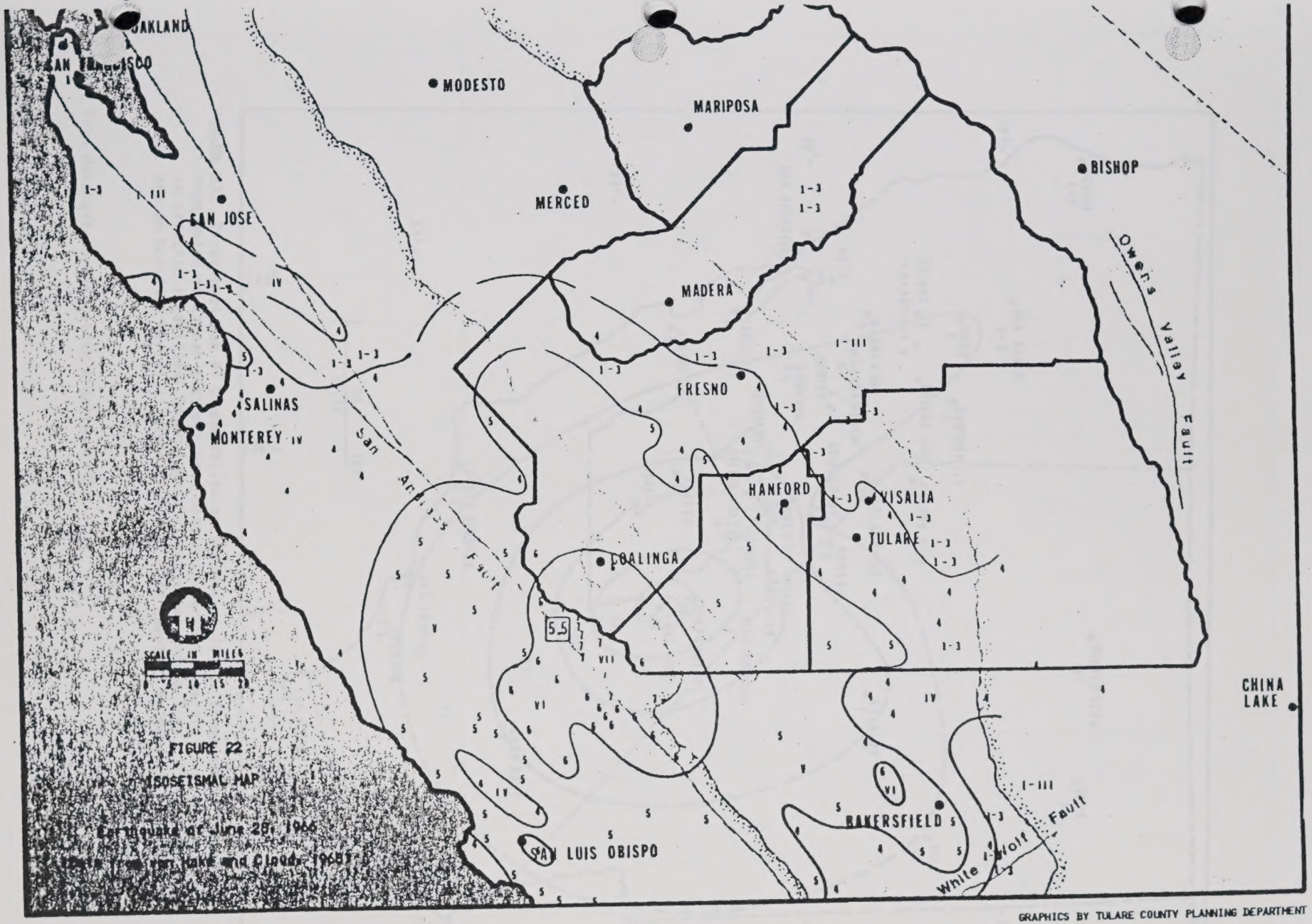

FIGURE 22

ISOSEISMAL MAP

Earthquake of June 28, 1966

(Data from Ulrich and Cloud, 1968)

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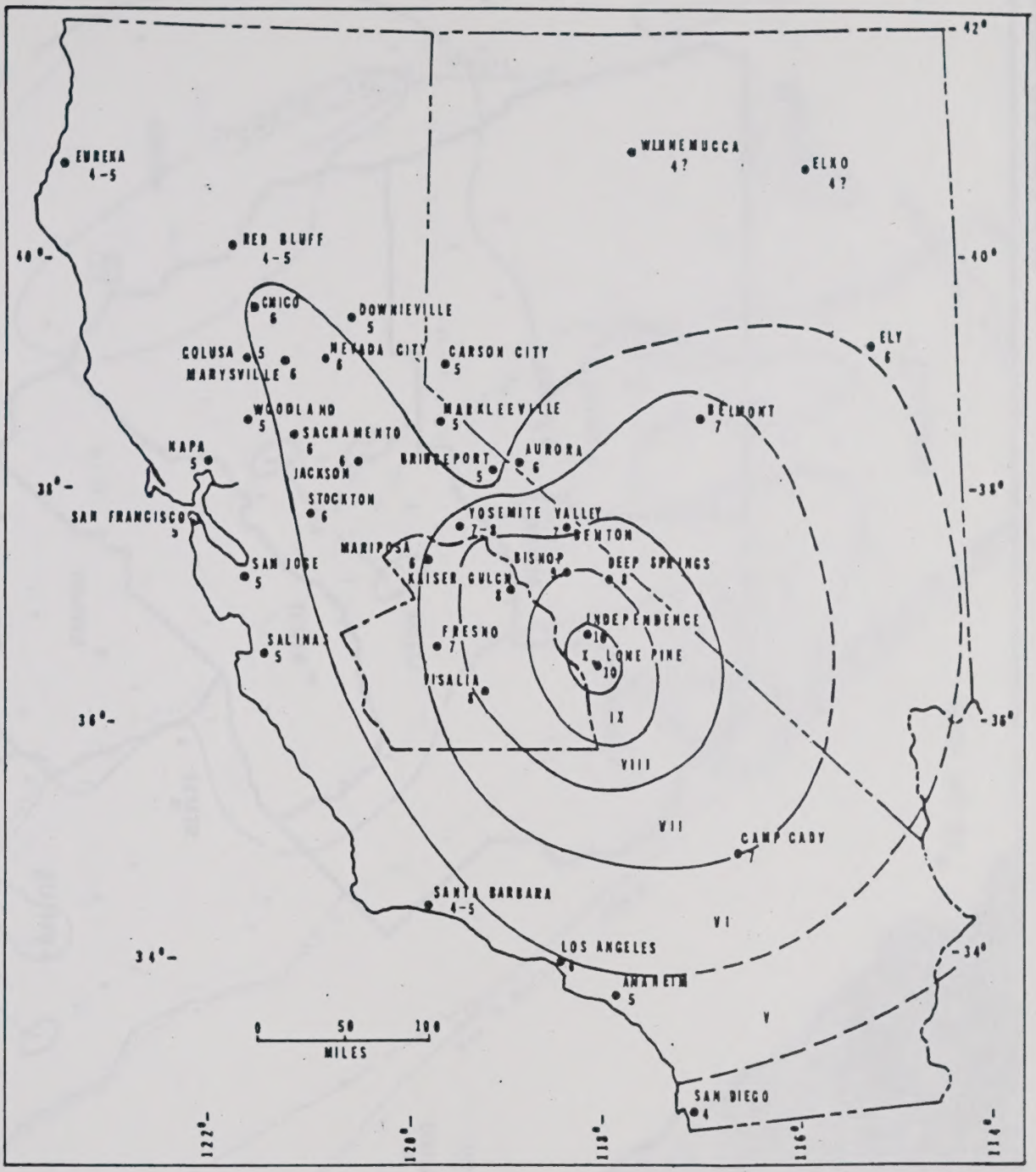


FIGURE 23. Isoseismal map of Owens Valley earthquake of 1872. Towns marked are those from which newspaper accounts were obtained. Arabic numerals give intensities at specific localities; Roman numerals give zonal intensities. All intensities are on Modified Mercalli intensity scale. Map compiled by Roger W. Greensfelder.

From Oakshott, Greensfelder & Kahle, 1972.

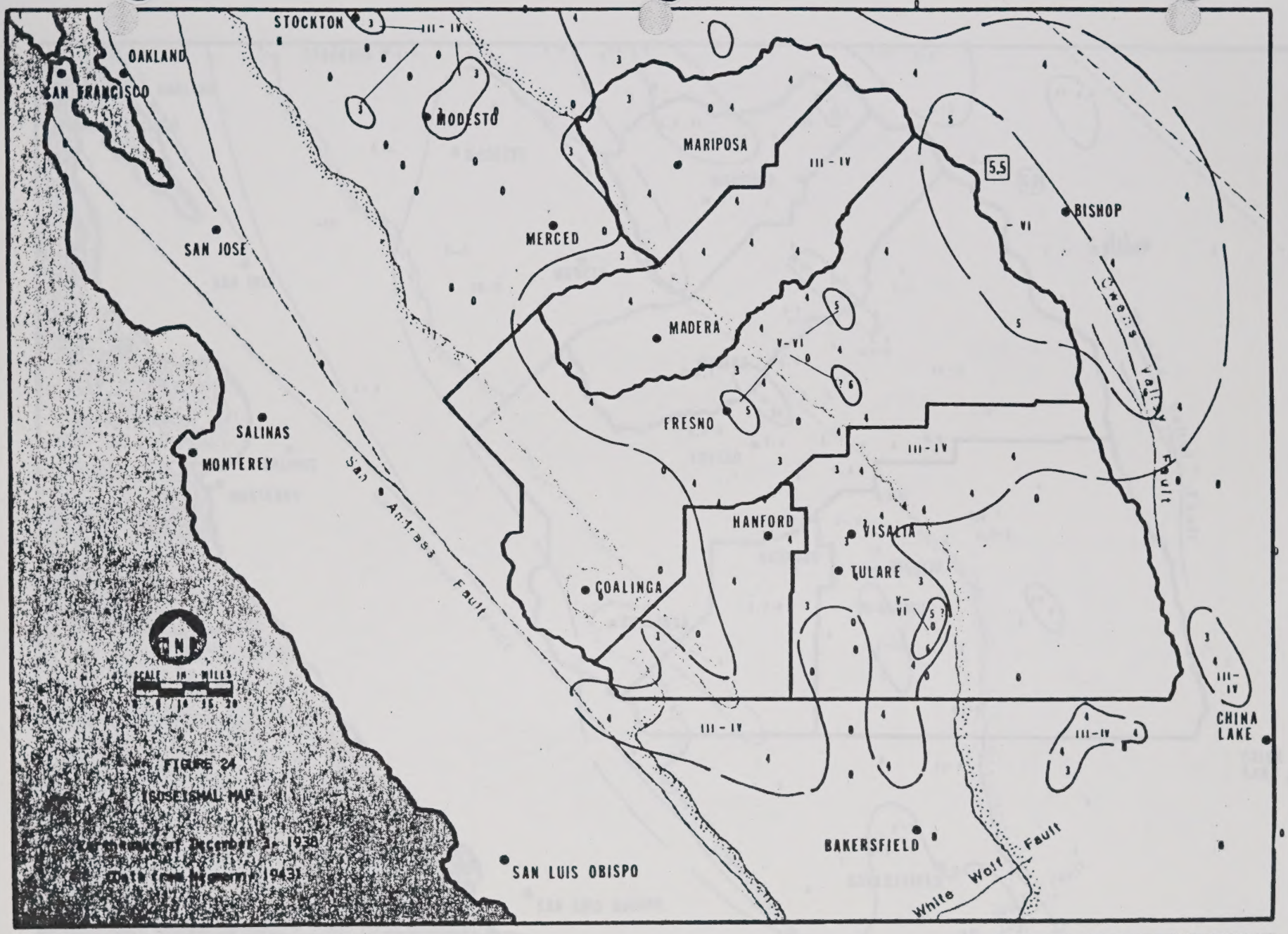


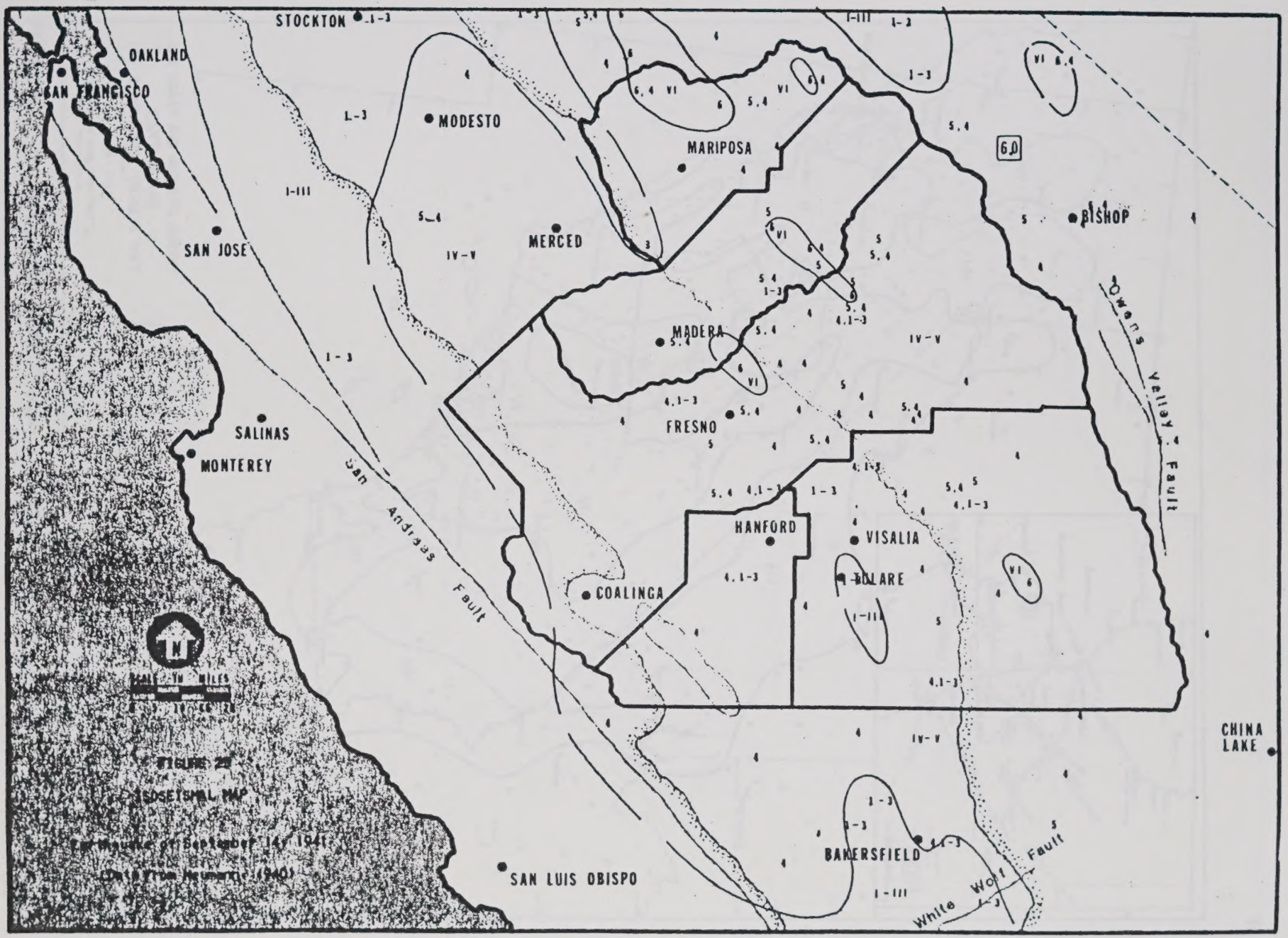
FIGURE 24

ISOSEISMAL MAP

Earthquake of December 3, 1938

Data from Hagerman, 1943

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT



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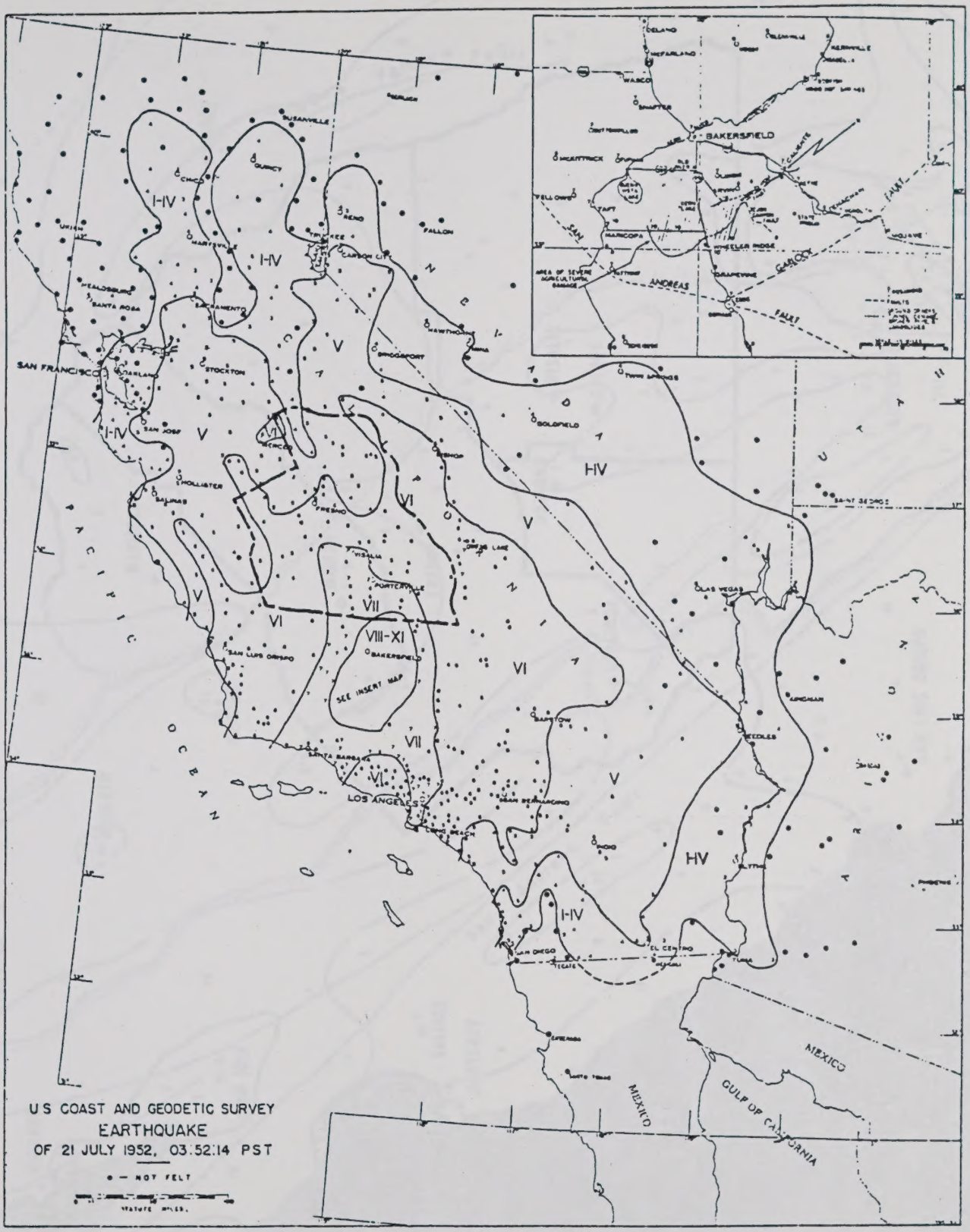
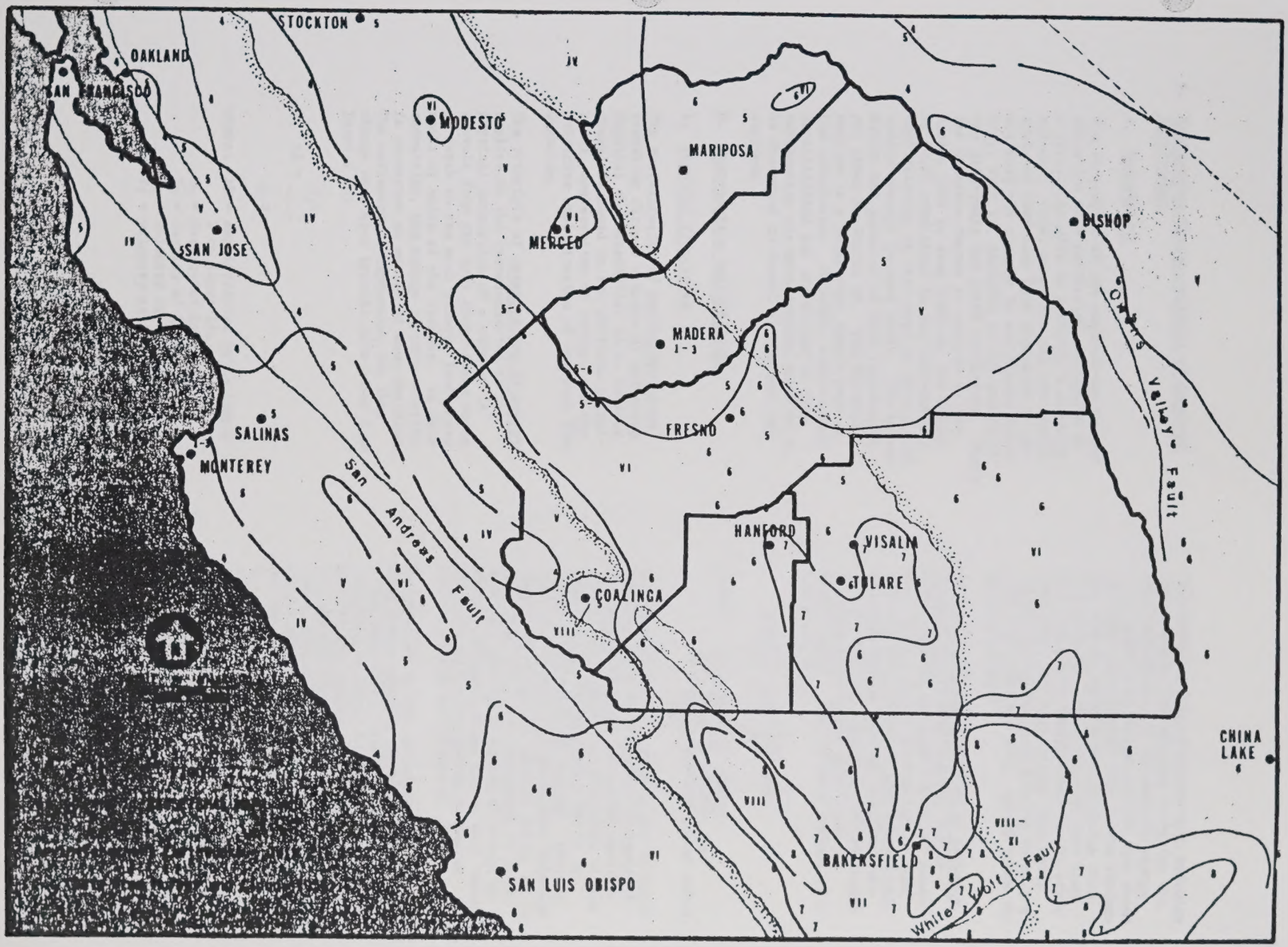


FIGURE 26. ISOSEISMAL MAP (CALIFORNIA) Arvin-Tehachapi earthquake of July 21, 1952, from Neuman & Cloud, 1955



GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

4. Engineering Characteristics of Expected Earthquakes

a. Methodology

The derivation of the engineering characteristics of a particular earthquake at a particular site is normally a two-step process. These steps are the two considerations that have been discussed in describing the changes in earthquake intensity; that is, distance to the source of the earthquake and local conditions. Where the distance factor is treated as the travel path in deep bedrock, the effect of local conditions is the near-surface amplification of the waves as they travel upward through layered rocks. The mathematics and geometry of this calculation are shown in Figure 28. The distance problem is a relatively simple part of the calculation. However, near-surface amplification and the choice of type earthquakes are more complex problems to be discussed in detail in the next two sections.

b. Near-Surface Amplification

1. Physical Principles

The amplification of earthquake waves traveling through a media of differing physical characteristics (i.e. layered rocks) is based on two physical principles: conservation of energy, and the selective amplification of resonant frequencies.

The principle of conservation of energy applies to the transformation of the physical properties of a wave as it travels from the very fast, dense rocks at depth to the much slower, less dense rocks or soils at the surface. In this conversion, the energy of wave velocity is converted to energy of wave amplitude. The mathematical expression for this change as a wave travels from layer 1 to layer 2 is:

$$AR = \frac{D_2 V_2}{D_1 V_1}$$

where: AR = amplification ratio (layer 2 to layer 1),
D_1 = density of layer 1,
D_2 = density of layer 2,
V_1 = velocity of layer 1, and
V_2 = velocity of layer 2.

The above equation involves both velocity and density, but velocity is by far the most important. In the overall change from granite at depths greater than about 100 feet to a typical soil at the surface, the density will typically change from 2.7 to about 1.5; a ratio of less than 2:1. Velocity (shear-wave) on the other hand will typically change from about 11,000 ft/sec to less than 500 ft/sec; a ratio of more than 20:1, and 10 times the density change.

The selective amplification of resonant frequencies is more complex, but in simple terms, the rock layers act somewhat like a series of organ pipes that amplify waves of particular frequencies. The frequencies that are amplified are those that form a one-quarter-wavelength standing wave in the layer, and all higher modes. The dominant periods of a layer are thus:

$$T = \frac{4}{1}\frac{H}{V}, \frac{4}{3}\frac{H}{V}, \frac{4}{5}\frac{H}{V} \text{ etc.}$$

where: T = dominant period,
H = layer thickness, and
V = layer velocity (shear wave).

For most sites, with many layers of varying thickness and a gradual increase of velocity with depth, selective amplification is secondary in importance to the more general amplification due to decreasing velocity and density. However, where there is a very pronounced velocity change at relatively shallow depth, as in the Mexico City area discussed in Introduction, the concentration of energy in a narrow frequency range can be very important for structures having a similar natural period of vibration.

In addition to the two principles considered above, damping can be important for sites with thick layered sequences. Waves traveling in fast, dense rocks such as granite are almost unaffected by damping, but unconsolidated materials such as soils, soft sands and shales can effectively damp earthquake waves if they are present in sufficient thickness. Overall, the effect is to cancel a part of the wave amplification of the slow, less dense rocks, because rocks with high amplification characteristics generally have high damping factors. For damping to be effective, however, thick layers are required. Thus, low velocity materials may be "good" or "bad." If, they are present as a relatively thin layer (15-100 feet), amplification may be very significant. However, if they are present as very thick layers (several thousands of feet), damping can be effective in reducing the amplification normally expected at sites underlain by low velocity rocks.

From the discussion above it is apparent that the most important physical characteristic of a site is the velocity or velocities of the layers underlying the site. Density is less important, and it can be estimated from velocity if the rock types are known. Damping is important for thick sections, and it too is closely related to velocity. Thus, if the velocity of the wave type of interest is known, the density and damping can generally be estimated to an acceptable degree of accuracy.

Earthquake shaking is the result of complex combinations of several types of vibrational waves. The primary components of earthquake waves are the so-called body waves that travel through the deeper parts of the earth's crust. Body waves include the primary (P-wave) or compressional waves and the secondary (S-wave) or shear waves. For waves traveling at depth, and refracted upward to the site (Figure 29), the P-waves, vibrating parallel to the propagation direction, dominate the vertical component of shaking. The S-waves arrive later and vibrate perpendicular to the direction of propagation; they make up the major part of the damage inducing, horizontal components of shaking. Thus, it is the shear waves that are of primary importance in the analysis of earthquake shaking.

2... Velocity Analysis

As developed in the previous section, it is shear-wave velocity that is the dominant physical parameter in the analysis of the near-surface amplification characteristics of a particular site. The problem is that the shear-wave velocity of rocks is difficult to measure, and is not normally available from studies for other purposes. P-wave velocity, however, is commonly measured at shallow depths to determine the excavation characteristics of rocks, and is the wave type recorded by oil companies in their seismic prospecting. Shear-wave studies have been conducted in other areas (e.g. Duke et al, 1971), and the ratios of S-wave to P-wave velocities developed from these studies can be used to estimate S-wave velocity from the measured P-wave velocity.

P-wave velocity data was contributed by the Standard Oil Company of California (see Acknowledgements), and consists of three types of data distributed generally within the Five-County area as listed below:

1. Deep well velocity surveys with control points at 500 to 1000 foot intervals, or continuous sonic logs of deep wells with or without check shots at similar intervals, located primarily in the areas of greater oil potential in the western and southern parts of the Valley and along the western foothills.

2. Shallow velocity (0-100 feet) from reflection seismograph data, primarily multiple up-hole shots or first-break refraction analysis, available primarily for the central and western parts of the Valley.

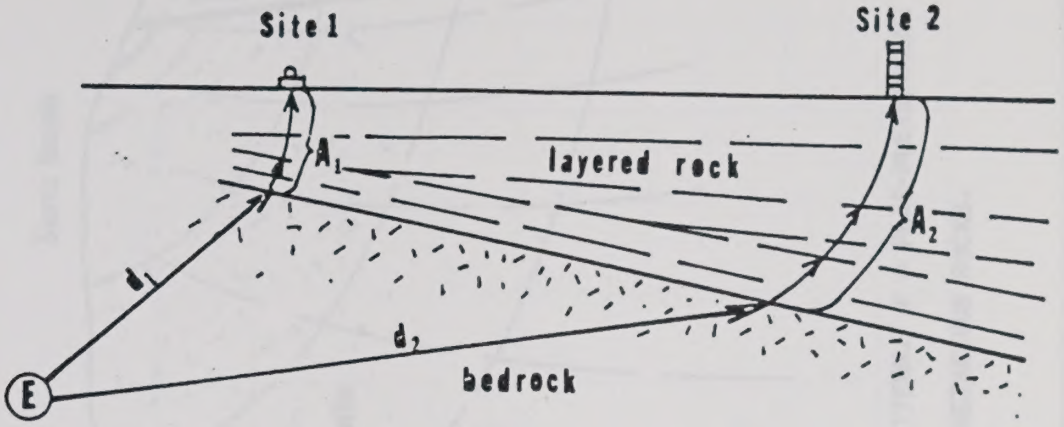
3. Deep up-hole (0-500 feet) velocity surveys available from more recent work in the western part of the Valley, primarily in the vicinity of Interstate 5.

Each of the above types of data tend to supplement each other. The deep well surveys are limited to that part of the well below surface casing which in the Five-County area is often below 1,000 ft. For the more recent surveys, a deep up-hole may be available down to 400 or 500 feet. The shallow velocity data is obtained for control of the so called "depth of weathering," and is limited to intervals down to about 100 feet. The more recent up-hole cable data helps to fill the gap between the shallow data (down to 100 feet) and the deep well data (below 1000 feet), but this information is limited. Thus, to compile complete velocity data for a particular site, some input from each of the three source types is desirable.

Another aspect of the data distribution is that it is not available, or is old and of rather poor quality, for areas generally east of Highway 99. For this reason, and to supplement and check the data available at the surveyed locations, the three types of velocity data have been analyzed by a number of different methods. These include plotting velocity against depth, and the plotting and [illegible]ring of the areal distribution of [illegible]ty in the three shallowest veloc[illegible]ers. The principal conclusions [illegible]ved from this analysis are as follows:

1. Shallow P-wave velocity averages about 2000 ft/sec and is not less than 1000 ft/sec at any of the locations surveyed (Figure 30).

2. The base of the shallow velocity layer compares well with the top of the water table, but a precise comparison cannot be made because of the complex fluctuations of the water table in recent years.



The spectrum, S_{V1}, of the earthquake, E, recorded at site 1, at distance d, from the source of the earthquake is:

$$S_{V1} = \frac{E\ A_1}{d_1}$$

where A is the near-surface amplification of the bedrock motion, damping in bedrock is negligible, and spreading is cylindrical. Likewise, the spectrum at site 2 is:

$$S_{V2} = \frac{E\ A_2}{d_2}$$

Therefore:

$$S_{V2} = S_{V1}\ \frac{d_1}{d_2}\ \frac{A_1}{A_2}$$

Where S_{V1}, S_{V2}, A_1, and A_2 are complex functions of frequency.

Figure 28. Geometry and mathematics of computation of the engineering characteristics of an earthquake.

SOURCE: ENVICOM

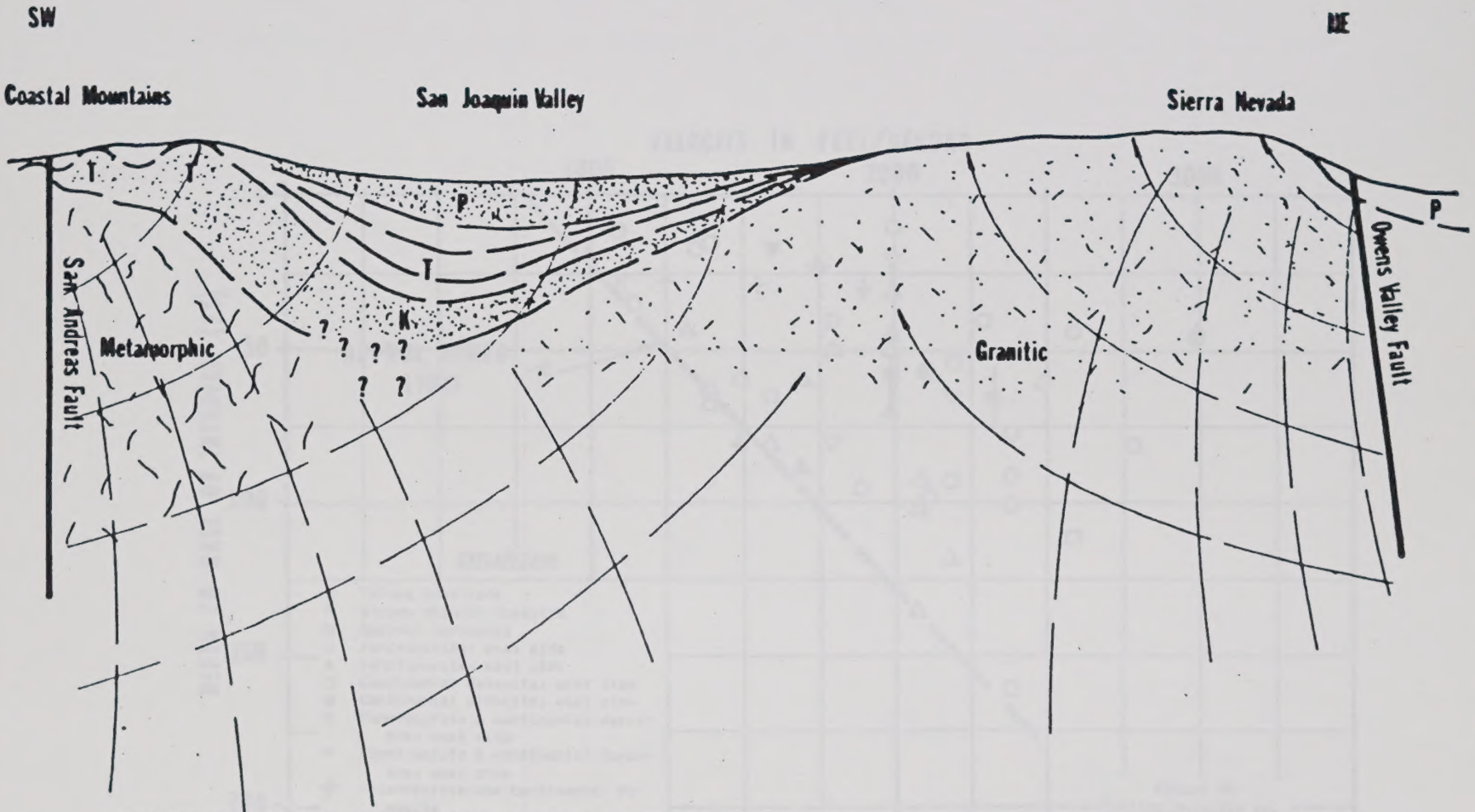


FIGURE 29 GENERALIZED GEOLOGIC CROSS SECTION WITH WAVE PROPAGATION PATTERN. P = PLIO-PLEISTOCENE ROCKS; T = MIDDLE AND LOWER TERTIARY ROCKS; AND K = UPPER CRETACEOUS ROCKS.

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

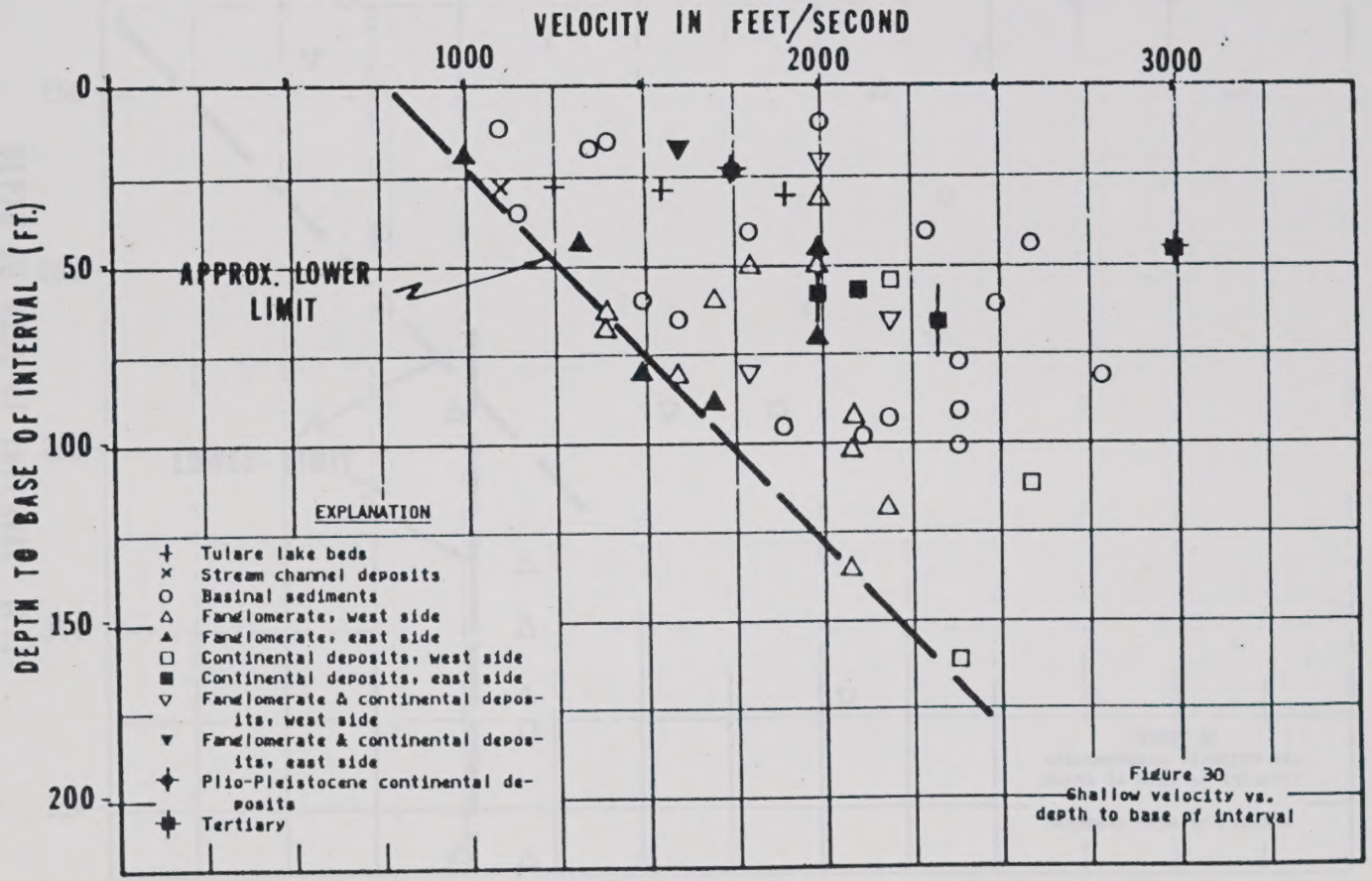


Figure 30
Shallow velocity vs. depth to base of interval

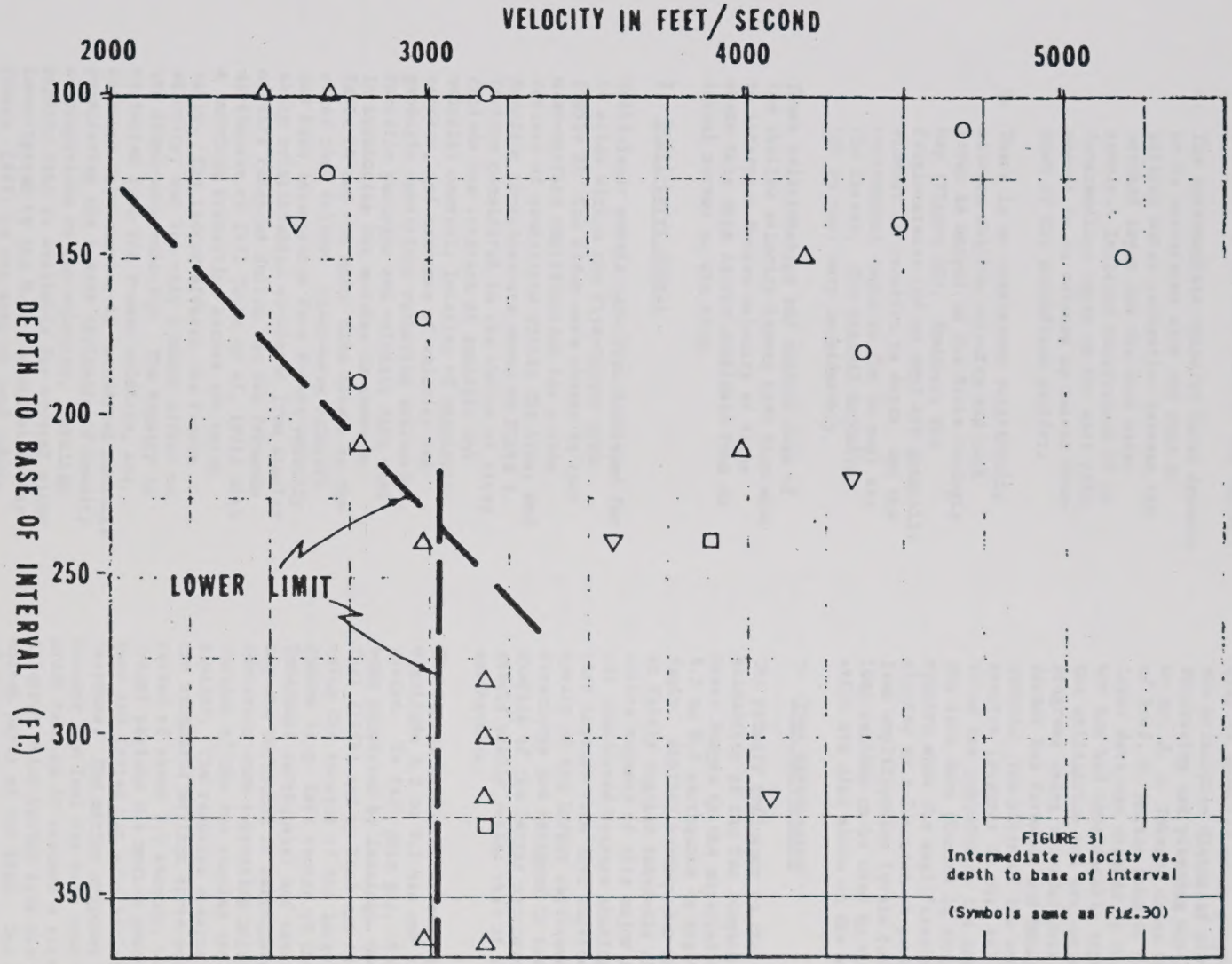


FIGURE 31
Intermediate velocity vs. depth to base of interval

(Symbols same as Fig.30)

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

3. An intermediate layer with velocities of 2500 to 4500 ft/sec (Figure 31) is present on the west side of the Valley.

4. The intermediate velocity layer appears to be associated with the zone of partial water saturation between the perched layer and the deep water levels. Isolated occurrences of an intermediate layer on the east side appear to be related to recent drawdown of the unconfined aquifer.

5. There is no consistent relationship between shallow velocity and rock group as mapped on the State Geologic Map (Figure 30). However, the fanglomerates (Qf on map) are generally slowest in relation to depth, and the continental deposits (Qc on map) are the faster. The basinal deposits (Qb on map) vary considerably.

These relationships and contour maps of the shallow velocity layers have been used to interpret P-wave velocity at sites where this data is not available from an actual survey at the site.

3. Multi-Layer Models

Multi-layer models have been developed for 14 sites within the Five-County area. (Table 9) The sites were chosen to test near-surface amplification for a wide variety of conditions within the area, and specific locations are shown on Plate I. Factors considered in the choice of sites include the location of geologic and velocity control, location of population centers, and extremes of velocity and geologic conditions requiring evaluation. Specific geologic and velocity data used in developing the modules is shown on Table 10 and the model data sheets on the pages that follow. Shear-wave velocity has been interpreted from P-wave velocity using relationships developed from studies of data recorded during the San Fernando earthquake of 1971 (Duke et al, 1971) with a smoothed transition across the water table. The latter affects the P-wave velocity, but has only a minor effect on the shear-wave velocity. The density is estimated from the P-wave velocity, and, although approximate, is considered adequate considering the lesser influence of density as comparison to the velocity. Detailed density data is available for several sites investigated by the U.S. Geological Survey (Meade, 1967) in the area of land subsidence on the west side of the Valley. The very low densities reported even at depths of 1500 to 2000 feet were tested at Site 7 (Cantua Creek).

The near-surface amplification characteristics for each of the sites were evaluated by computer using programs based on the principles discussed previously. Processing and plotting was accomplished by Mr. J. A. Johnson under the supervision of Prof. C. Martin Duke of U.C.L.A. All input data was checked by Mr. Johnson who has had considerable experience in the utilization and evaluation of these programs using recorded data from the recent San Fernando and Managua earthquakes. The plots of the amplification spectra (Figures 32 thru 46) for the 14 sites are included on the pages following the site data (Tables 11 thru 24). These spectra show the amplification factor plotted as a function of period. Generalized amplification levels for short and long periods to be used in the microzonation are also shown on the plots.

c. Type Earthquakes

The primary influence on the future seismicity of the San Joaquin Valley and Coast Ranges is the expected magnitude 8.3 to 8.5 earthquake on the San Andreas fault. Smaller earthquakes which occur at fairly regular intervals along the active segment of this major fault are not considered because shaking will be less intense than that expected as a result of the larger earthquake. If structures are designed to resist the shaking of the larger earthquake, they should easily resist that of the smaller earthquakes.

The strong motion of an earthquake of magnitude 8.3 to 8.5 has not been recorded. To fill this gap, the motion has been simulated by Jennings, Housner and Tsai (1968) and by Seed and Idriss (1969) using the records of the larger earthquakes (e.g. Taft record of the Arvin-Tehachapi earthquake) and theory regarding the variation in earthquake characteristics with increasing magnitude. The results of the two studies are very similar. The response spectra of the two simulated motions agree well up to a period of about 2.0 seconds, but for the longer periods the motion proposed by Seed and Idriss has substantially lower response. The motion proposed by Jennings, Housner and Tsai has been used in this study because it assumes a site on firm alluvium which better fits the more populated parts of the area. One component of this motion is shown as Figure 47, and its response spectrum is shown as Figure 48.

The smaller earthquakes from the Owens Valley fault group are within the range of earthquakes that have been recorded and studied. Data on the characteristics of earthquakes of this magnitude (6.0-7.0) are not a significant problem.

TABLE 9
SITES INVESTIGATED FOR NEAR-SURFACE
AMPLIFICATION CHARACTERISTICS

Site Number	General Location	Designation and Nearest Town or City
1.	Sec. 20, T23S, R26E	South-central Tulare County near Earlimart
2.	Sec. 30, T23S, R22E	Near Trico gas field, west of Alpaugh
3.	T23S, R20E	East of Kettleman Hills, southeast of Kettleman City
4.	Sec. 2, T21S, R16E	Guijarral Hills, east of Coalinga
5.	Sec. 8, T19S, R22E	Hanford
6.	SW 1/4, T18S, R25E	Visalia
7.	Sec. 14, T17S, R15E	Cantua Creek, west of Five Points
8.	Sec. 14, T15S, R17E	Raisin City
9.	T13S, R20E	Fresno
10.	Sec. 29, T14S, R13E	Cheney Ranch, Southwest of Mendota
11.	W 1/2, T13S, R16E	Gill Ranch, northeast of Mendota
12.	N 1/2, T13S, R21E	Clovis
13.	Sec. 28, T11S, R12E	North-central area, south of Dos Palos
14.	T21S, R15E	Jacalitos oil field, south of Coalinga

TABLE 10
SOURCES OF DATA FOR MULTI-LAYER MODELS

Velocity and Density:

1. Shallow uphole or refraction data from seismic survey.

2. Deep uphole from seismic survey.

3. Regional analysis of shallow and intermediate velocity data.

4. Well survey, interval velocity.

5. Well survey, with sonic log.

6. Estimated from nearest well surveys using geologic formation and depth.

NOTE: The suffix "A" denotes that the data is based on a nearby survey. This data is considered to be intermediate in reliability between site data (1, 2, 4 and 5) and that from regional analysis (3 and 6).

Geological:

7. Geologic Map of California

8. Oil field data (Calif. Div. of Oil & Gas, 1961)

9. Correlation Section, San Joaquin Valley, Kingsburg to Tejon Hills (Amer. Assoc. Pet. Geol., 1969)

10. Correlation Section, Central San Joaquin Valley, Riverdale through Tejon Ranch (Amer. Assoc. Pet. Geol., 1958A)

11. Correlation Section, Westside San Joaquin Valley, Coalinga to Midway Sunset and across San Andreas Fault to Southeast Cuyama Valley (Amer. Assoc. Pet. Geol., 1959).

12. Correlation Section, Central San Joaquin Valley, San Andreas Fault to Sierra Nevada Foothills. (Amer. Assoc. Pet. Geol., 1957).

13. Correlation Section, Central San Joaquin Valley, Rio Vista through Riverdale (Amer. Assoc. Pet. Geol., 1958B).

(Continued)

TABLE 10 Cont.

General Geological:

14. Compaction of sediments underlying areas of land subsidence in Central California (Meade, 1968)

15. Madera area investigation (Calif. Dept. of Water Resources, 1966)

16. Physical and hydrologic properties of water-bearing deposits in subsiding areas in Central California (Johnson et. al., 1968)

17. Geology of the late Tertiary and Quaternary water-bearing deposits of the southern part of the San Joaquin Valley, California (Croft, 1969)

18. Geology, hydrology and water quality in the Fresno area, California (Page and Le Blanc, 1969)

19. Geology, hydrology and quality of water in the Madera area, San Joaquin Valley, California (Mitten et. al., 1970)

20. Groundwater conditions and potential pumping resources above the Corcoran Clay, San Luis Unit, Central Valley Project, California (U. S. Bureau of Reclamation, 1965)

21. Geology and construction materials data, earthwork and structures, Kettleman City to Avenal Gap, mile 174.8 to 187.1 (Calif. Dept. of Water Resources, 1965)

SITE CHARACTERISTICS

TABLE: 11 SITE NO: 1

AREA: South-Central Tulare Co. LOCATION: Sec. 20, T23N,R26E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	75	Qc	75	7	1600	1A	720	100
75	115		190	9	2500	3	1125	115
190	110	Kern River		9	6200	1A	2900	140
300	1360	(L.Pleist. & Plio.)		9	7000	5	3500	144
1660	640			9	7500	5	3750	144
2300	2200	(U. & L. Miocene)		9	8500	5	4250	144
4500	100	Granite basement		9	14,000	5	9100	153
4600	10,000			9	19,000	5	12,350	170

SITE CHARACTERISTICS

TABLE: 12 SITE NO: 2

AREA: Near Trico gas field LOCATION: Sec.30,T23S,R22E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	5	Ql	5	7	1500	1	675	106
5	50	(Tulare Lake Sediments)		7	5600	1	1300	134
55	1345	Kern River/Tulare		4	5200	4,5	2450	122
1400	500	(Pleist. & U.Plio.)		4	5400	4,5	2700	122
1900	600			4	5900	4,5	2950	125
2500	200			4	6900	4,5	3450	131
2750	550	San Joaquin		4	6500	4,5	3250	128
3250	200	& Etchegoin		4	8500	4,5	4250	137
3450	300	(Pliocene)		4	6600	4,5	3300	128
3750	4250			4	7000	6	3700	131
8000	4000			4	8000	6	4800	144
12,000	1000	(Miocene)		4	9500	4A	5700	144
13,000	1200	Panoche Brown Mtn. Ss.		4	15,000	4A	9000	156
14,200	500	Ragged Valley Sh.		4	14,500	6	8700	156
14,700	500	Joaquin Ridge Ss.		4	16,000	6	9600	160
15,200	100	Granitic (?) basement		4	15,500	6	10,100	162
15,300	10,000			4	19,000	6	12,350	170

SITE CHARACTERISTICS

TABLE: 13 SITE NO: 3

AREA: East of Kettleman Hills LOCATION: T23S, R20E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	5	Ql & Qb		7	1250		560	100
5	25	Kern River/Tulare		12	5000		1000	125
30	1400	(Plio. - Pleist.)		12	5600		2500	131
1430	1820	? ?		12	6300		3150	134
3250	1350	San Joaquin &		12	7800		3900	137
4600	900	Etchegoin		12	8400		4200	137
5500	1000	(Pliocene)		12	9200		5060	140
6500	1000			12	10,000		5500	144
7500	500	U.Mio. Santa Margarita Ss.		12	9500		5225	140
8000	1600	U.Mio. McClure Sh.		12	9800		5390	144
9800	1200	M.&L.Mio. Temblor		12	10,500		6300	147
11,000	1200			12	14,500		8700	159
12,200	800	Olig. + U. Eo. Sh.		12	12,000		7200	150
13,000	300	Eo. Gatchell Ss.		12	15,000		9000	162
13,300	700	Eo. Cantua Sh.		12	13,500		8100	156
14,000	900	Moreno Sh.		12	14,000		8400	159
14,900	1600	U. Cret. Panoche Brown Mtn. Ss.		12	15,500		9300	162
16,500	800	Ragged Valley Ss.		12	14,500		8700	159
17,300	700	Joaquin Ridge Ss.		12	16,000		9600	165
18,000	100	Granitic (?) basement		12	17,000		11,050	170
18,100	10,000			12	18,000		11,200	170

SITE CHARACTERISTICS

TABLE: 14 SITE NO: 4

AREA: Guijarral Hills (east of Coalinga) LOCATION: Sec.2, T21S, R16E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	25	Q-P		7	1800	1	810	109
25	280	Tulare/Kern River		11	3600	3	1620	125
300	600	(Plio. - Pleist.)		11	6600	4	3170	131
900	1000	San Joaquin		11	7200	4	3600	131
1900	1000	(Plio.)		11	7800	4	3900	134
2900	1000	Etchegoin (Plio.)		11	8600	4	4300	140
3900	3100			11	9300	4	4930	144
7000	1000	(U. Mio.)		11	12,300	4	6700	153
8000	600	(M. Mio.)		11	14,000	4	7700	159
8600	2600	Eo. + Olig.		11	15,000	6	9000	162
11,200	700	U. Cret. Panoche: Moreno Sh.		11	14,500	6	8700	165
11,900	1800	U. Cret. Panoche: Brown Mtn. Ss.		11	16,500	6	9900	165
13,700	700	U. Cret. Panoche: Ragged Valley Sh.		11	15,000	6	9000	165
14,400	800	U. Cret. Panoche: Joaquin Ridge Ss.		11	16,500	6	9900	165
15,200	100	Granitic (?) basement		11	16,000	6	10,400	165
15,300	10,000			11	20,000	6	13,000	172

SITE CHARACTERISTICS

TABLE: 15 SITE NO: 5

AREA: Hanford LOCATION: Sec.8, T19S, R22E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	40	Qf		7	1300	1	590	100
40	30	Tulare/Kern River		9,10	3000	2A	1350	112
70	930	(Plio-Pleist.)		9,10	6000	2A	2900	125
1000	950			9,10	6800	4	3400	131
1950	1000			9,10	7300	4	3650	134
2950	1000	(Pliocene)		9,10	8350	4	4200	137
3950	550			9,10	8700	4	4350	140
4500	200	Santa Margarita (U.Mio.)		9,10	7400	4	3700	134
4700	2600	(M. & L. Mio.)		9,10	8900	4	4900	140
7300	1800	(Eo. + U. Cret.)		9,10	9600	4	5300	144
9100	3900	(U. Cret.)		9,10	10,500	6	6300	147
13,000	100	Granite basement		9,10	14,000	4A	9100	149
13,100	10,000			9,10	19,000	4A	12,350	170

SITE CHARACTERISTICS

TABLE: 16 SITE NO: 6

AREA: Visalia LOCATION: SW1/4,T18S,R25E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	25	Qf		7	1400	1	630	103
25	75	Kern River		9A	6000	1	1300	110
50	200	(Pleist.+Plio.)		9A	6000	5A	2700	128
300	1300			9A	7000	5A	3290	128
1600	200	(U.Mio.)Santa Margarita		9A	6500	6	3250	128
1800	800	(M.&L.Mio.)		9A	8000		4000	137
2600	100	Granite basement		9A	14,000		9100	159
2700	10,000			9A	19,000		12,300	170

SITE CHARACTERISTICS

TABLE: 17

SITE NO: 7

AREA: Cantua Creek

LOCATION: Sec. 14, T17S, R15E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	48	Qf		7	2000	3	900	112
48	192	Kern River		9,12	3000	3	1350	119
240	760	(Plio. - Pleist.)		9,12	6000	3	2500	128
1000	1200	San Joaquin		9,12	6700	6	3000	131
2200	1500	Etchegoin		9,12	7700	6	3850	134
3700	1000	U. Mio. Santa Marg. McLure		9,12	8700	6	4350	137
4700	1800	Temblor		9,12	9200	6	5050	140
6500	1000	Kregenhagen		9,12	10,200	6	5600	147
7500	700	Loescher & Cat.		9,12	10,500	6	5800	147
8300	1500	Lower Hondo		9,12	10,700	6	5900	147
9800	1200	Cantua Ss.		9,12	8800	6	5250	140
11,000	600	Moreno Sh.		9,12	9600	6	5760	144
11,600	1200	U. Cret. Panoche Brown Mtn.		9,12	11,200	6	6720	150
12,800	800	Ragged Valley		9,12	12,500	6	7500	156
13,600	800	Joaquin Ridge		9,12	14,000	6	8400	162
14,400	100	Granite (?) basement		9,12	15,500	6	10,000	162
14,500	10,000			9,12	19,000	6	12,350	170

SITE CHARACTERISTICS

TABLE: 18

SITE NO: 8

AREA: Raisin City

LOCATION: Sec. 14, T15S, R17E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	90	Qb		7	2000	1A	900	112
90	50	Kern River/Tulare		8,13	2700	1A	1215	115
140	860	(Plio. - Pleist.)		8,13	5800	2A	2600	134
1000	1000			8,13	6800	4A	3400	137
2000	1000			8,13	7500	4A	3750	140
3000	900			8,13	8400	4A	4200	144
3900	600			8,13	7200	4A	3600	137
4500	600	(U.Mio.) Santa Margarita		8,13	7200	4A	3600	137
5100	1400	(L + M. Mio.) Zilch		8,13	8800	4A	4850	140
6500	450	(Olig. + Eo.)		8,13	8400	4A	4600	137
6950	650	U. Cret. Moreno Sh.		8,13	9000	4A	4950	140
7600	4000	Panoche Ss.		8,13	10,500	4A	5800	147
11,600	100	Granitic basement		8,13	14,000	4A	9100	159
11,700	10,000			8,13	19,000	4A		

SITE CHARACTERISTICS

TABLE: 19 SITE NO: 9

AREA: Fresno LOCATION: T13S, R20E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	70	Qf & Qc		7	1600	1	720	106
70	100	Tulare/Kern River		12	6000	1	1200	112
170	330	(Plio. - Pleistocene)		12	6000	6	2700	125
500	1000			12	6500	6	3120	131
1500	1000			12	7000	6	3500	131
2500	1500	Mio.-U.Cret. Zilch		12	7500	6	3750	134
4000	100	Granitic basement		12	14,000	6	9100	159
4100	10,000			12	19,000	6	12,350	170

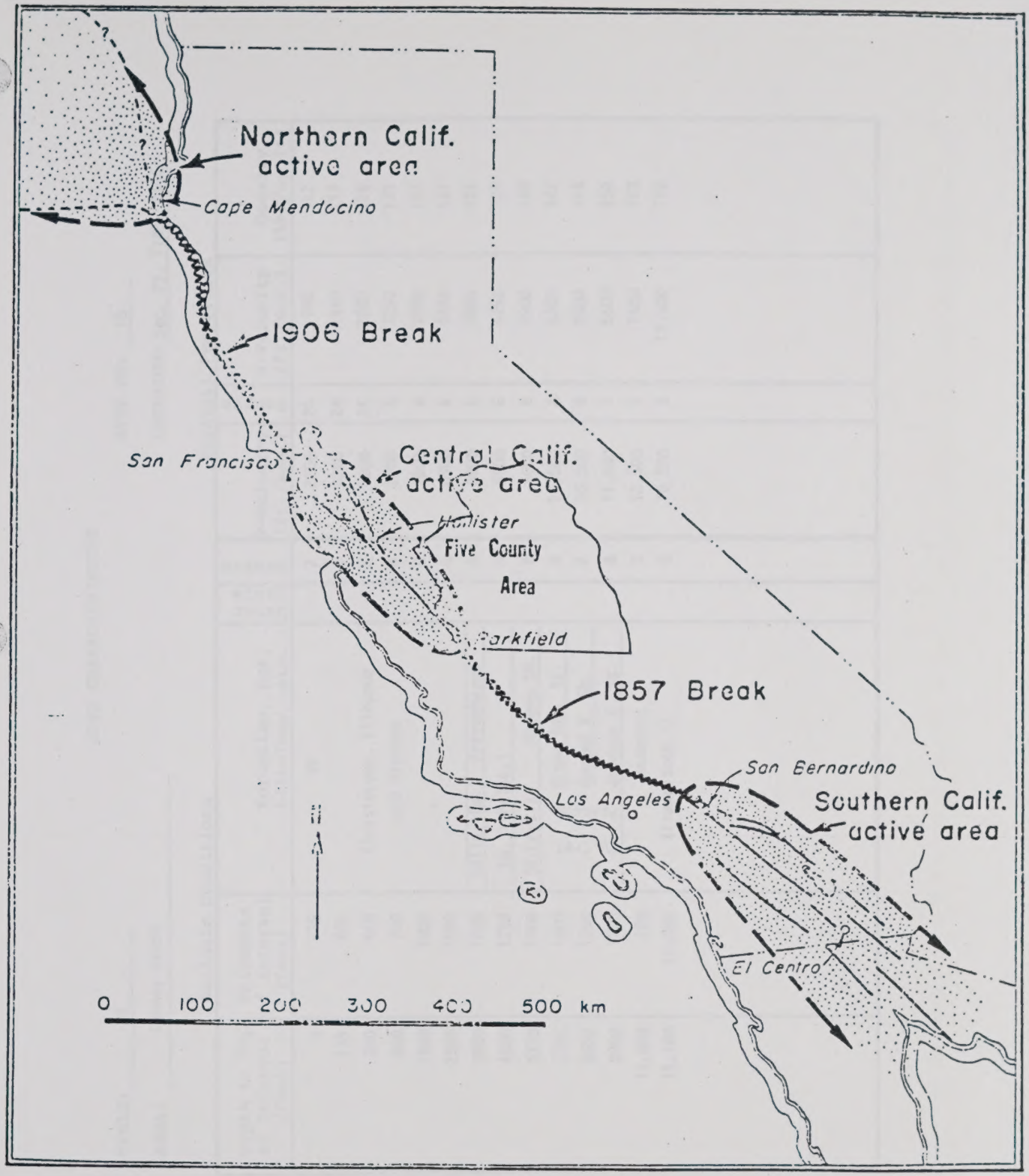


FIGURE 8 TYPES OF SEISMIC AND EARTHQUAKE ACTIVITY ON THE SAN ANDREAS FAULT.

FROM ALLEN, 1968

SITE CHARACTERISTICS

TABLE: 20

SITE NO: 10

AREA: Cheney Ranch

LOCATION: Sec. 29, T14S, R13E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	135	Qf		7	2200	2A	990	112
135	205			8	3200	2A	1440	119
340	460	Pleistocene, Pliocene		8	5800	2A	2600	128
800	700	and Miocene		8	6800	6	3250	131
1500	1000			8	7800	6	3900	134
2500	1000			8	8500	6	4250	137
3500	1000	(Olig.+Eo.) Kreyenhagen		8	8000	6	4000	134
4500	1250	Eo. + Paleo.)		8	8500	6	4250	137
5750	1400	(U.Cret.) Moreno Sh.		8	9000	6	4900	140
7150	1500	(U.Cret. Panoche Brown Mtn. Ss.		8	10,500	6	5700	147
8650	1250	Ragged V. Sh.		8	10,000	6	6000	144
9900	1200	Joaquin R. Ss.		8	11,000	6	6600	150
11,000	100	Basement		8	12,500	6	7500	153
11,100	10,000	(Franciscan ?)		8	19,000	6	12,300	170

SITE CHARACTERISTICS

TABLE: 21

SITE NO: 11

AREA: Gill Ranch

LOCATION: West half, T13S, R16E

Geologic Conditions				Physical Properties				
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	30	Qsc		7	1100	1	495	9
30	20	Kern River/Tulare		8,13	1500	1	675	106
50	250	(Plio. - Pleist.)		8,13	5800	6	2610	134
300	1200			8,13	6200	6	2975	134
1500	1400			8,13	6800	6	3400	134
2900	500	(U.Mio.) Santa Margarita		8,13	7200	6	3600	137
3400	900	(L.& M. Mio.) Zilch		8,13	8600	6	4300	140
4300	350	(Olig. + Eo.) Krey. & Dom.		8	8200	6	4100	137
4650	450	Moreno Sh.		8	8700	6	4350	140
5100	700	U. Cret. Ragged Valley Ss.		8	9500	6	5225	144
5800	3350	Panoche		8	10,000	6	5500	144
9150	100	Granitic basement		8	14,000	6	9100	159
9250	10,000			8	19,000	6	12,350	168

SITE CHARACTERISTICS

TABLE: 22

SITE NO: 12

AREA: Clovis

LOCATION: North half, T13S, R21E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	30	Qf		7	1600	1	720	106
30	70	Tulare/Kern River		12	6000	1	1200	112
100	400	(Plio. - Pleistocene)		12	6000	6	2700	125
500	1000			12	6500	6	3120	131
1500	500			12	7000	6	3500	131
2000	100	Granitic basement		12	14,000	6	9100	159
2100	10,000			12	19,000	6	12,350	170

SITE CHARACTERISTICS

TABLE: 23 SITE NO: 13

AREA: North Central LOCATION: Sec.28, T11S, R12E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	10	Qb		7	1100	1	490	97
10	90			13	5700	4	800	106
100	210	Tulare/Kern River		13	5700	4	2565	134
310	1090	(Plio.-Pleistocene)		13	6400	4	2880	137
1400	1800			13	7600	4	3800	140
3200	400	(U.Mio.) Santa Margarita		13	7200	4	3600	134
3600	1400	(Mio. & Olig. & Eo.)		13	8500	4	4250	140
5000	2000			13	9200	4	5060	144
7000	3000			13	10,000	4	5500	147
10,000	400	(U. Cret.)		13	11,000	4	6600	150
10,400	2600	? ?		13	13,500	4	8100	156
13,000	100	Granitic basement		13	14,000	6	9100	159
13,100	10,000			13	10,000	6	11,200	170

SITE CHARACTERISTICS

TABLE: 24

SITE NO: 14

AREA: Jacalitos Oil Field

LOCATION: T21S, R15E

Geologic Conditions					Physical Properties			
Depth to Top of Interval (feet)	Thickness of Interval (feet)	Formation, Age, Lithology, etc.	Water Table	Source	P-Velocity (ft./sec.)	Source	S-Velocity (ft./sec.)	Density (lbs/cu ft)
0	10	(surface weathering)		8,12	3000	6	1350	119
10	30	Etchegoin/Jacalitos		8,12	7000	6	3150	131
40	1960			8,12	8600	4	4120	137
2000	1000			8,12	9400	4	4700	144
3000	200	(U. Mio.) Reef Ridge Sh.		8,12	9000	4	4500	144
3200	200	(U. Mio.) McLure Sh.		8,12	9500	4	4750	144
3400	600	(M. Mio.) Temblor Ss.		8,12	10,500	4	5250	147
4000	800	(Olig. & Eo.) Kreyenhagen Sh.		8,12	10,000	4	5000	144
4800	200	(Eo.) Gatchell Ss.		8,12	10,500	4	5250	147
5000	600	U. Cret. Panoche Moreno Sh.		8,12	11,500	4	6325	150
5600	1800	U. Cret. Panoche Brown Mts. Ss.		8,12	12,500	6	6875	156
7400	700	U. Cret. Panoche Ragged Valley Sh.		8,12	12,000	6	6600	153
8400	800	U. Cret. Panoche Joaquin Ridge Ss.		8,12	14,000	6	7700	162
9200	100	Basement		8,12	15,000	6	9750	162
9300	10,000			8,12	19,000	6	12,350	170

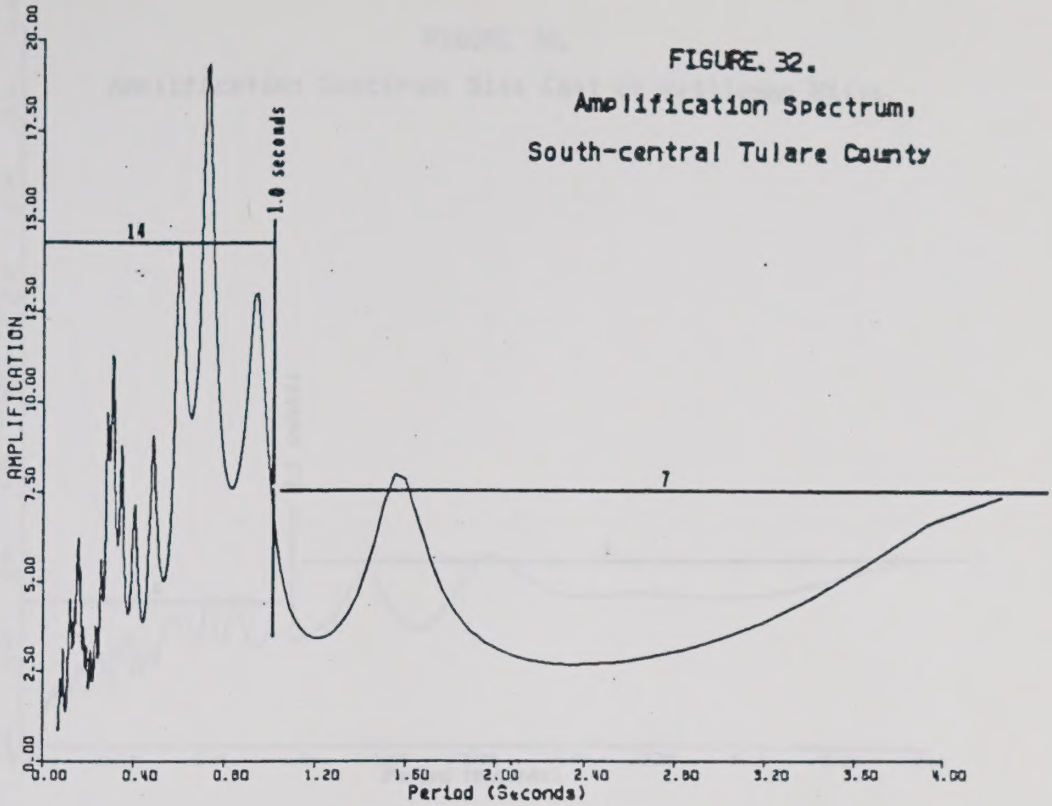


FIGURE 32.
Amplification Spectrum,
South-central Tulare County

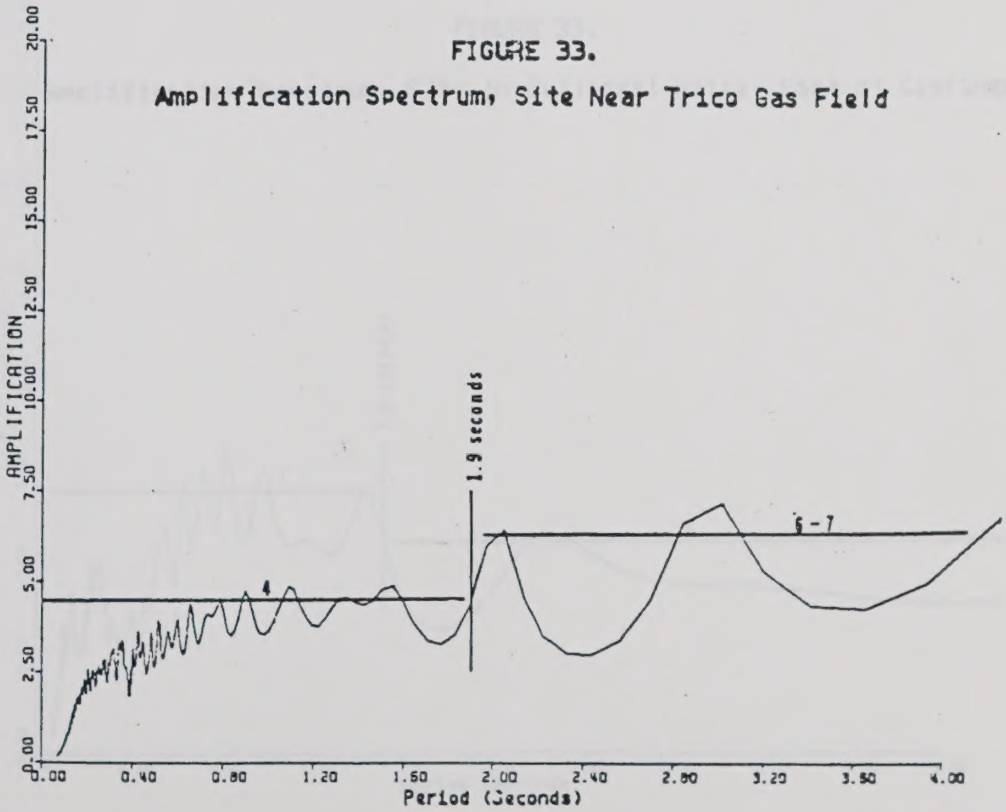


FIGURE 33.
Amplification Spectrum, Site Near Trico Gas Field

SOURCE: ENVICOM

FIGURE 34.

Amplification Spectrum, Site East of Kettleman Hills

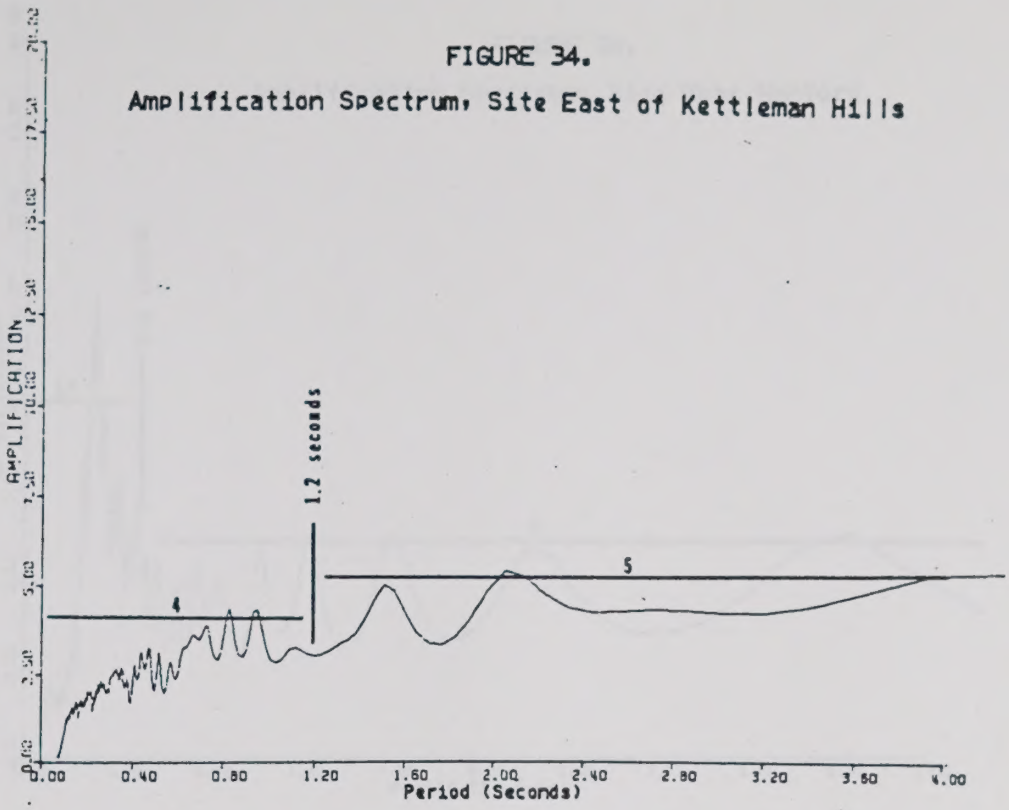
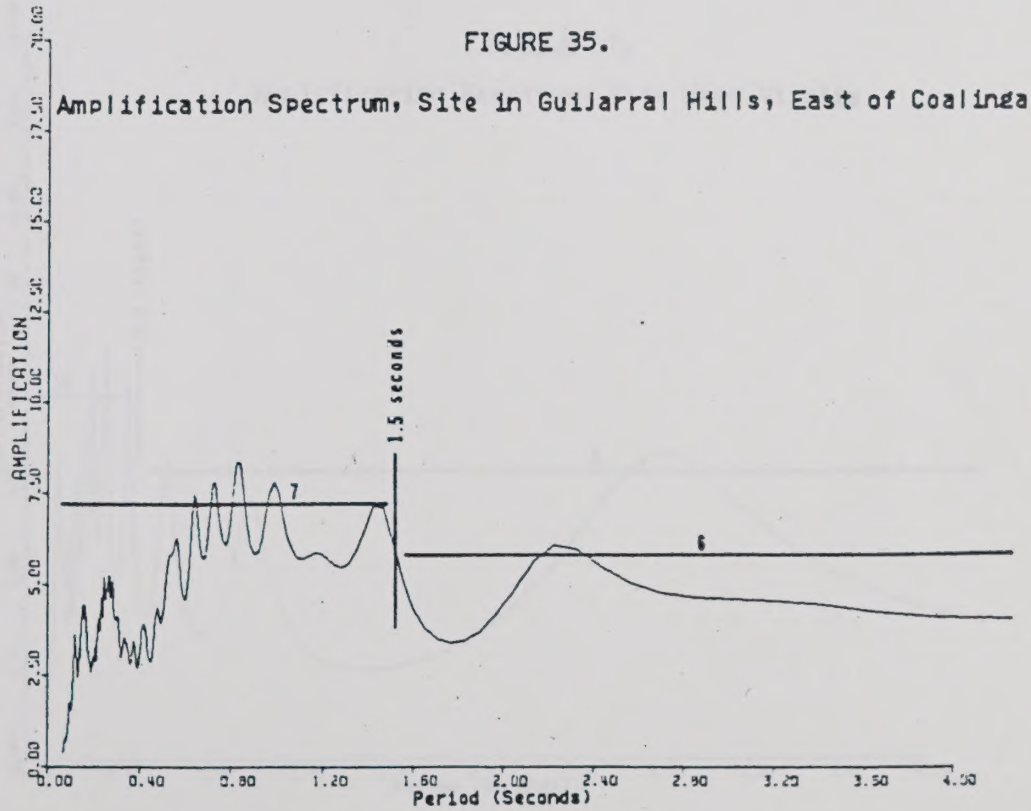


FIGURE 35.

Amplification Spectrum, Site in Guijarral Hills, East of Coalinga



SOURCE: ENVICOM

FIGURE 36.

Amplification Spectrum, Site Near Hanford

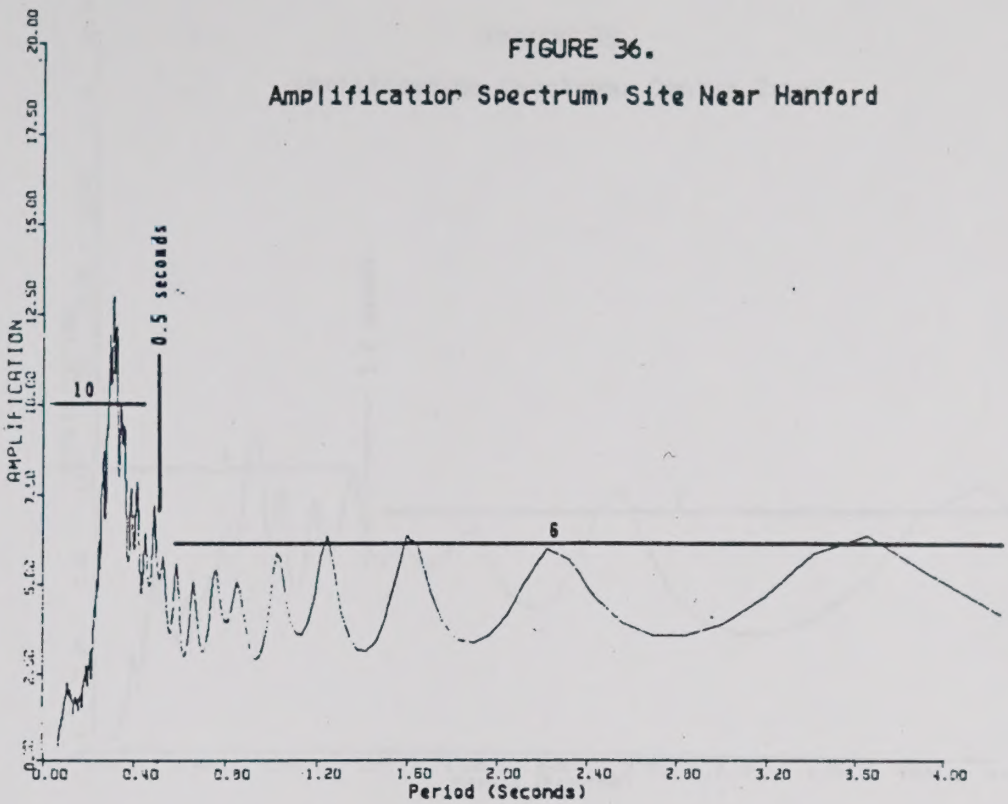
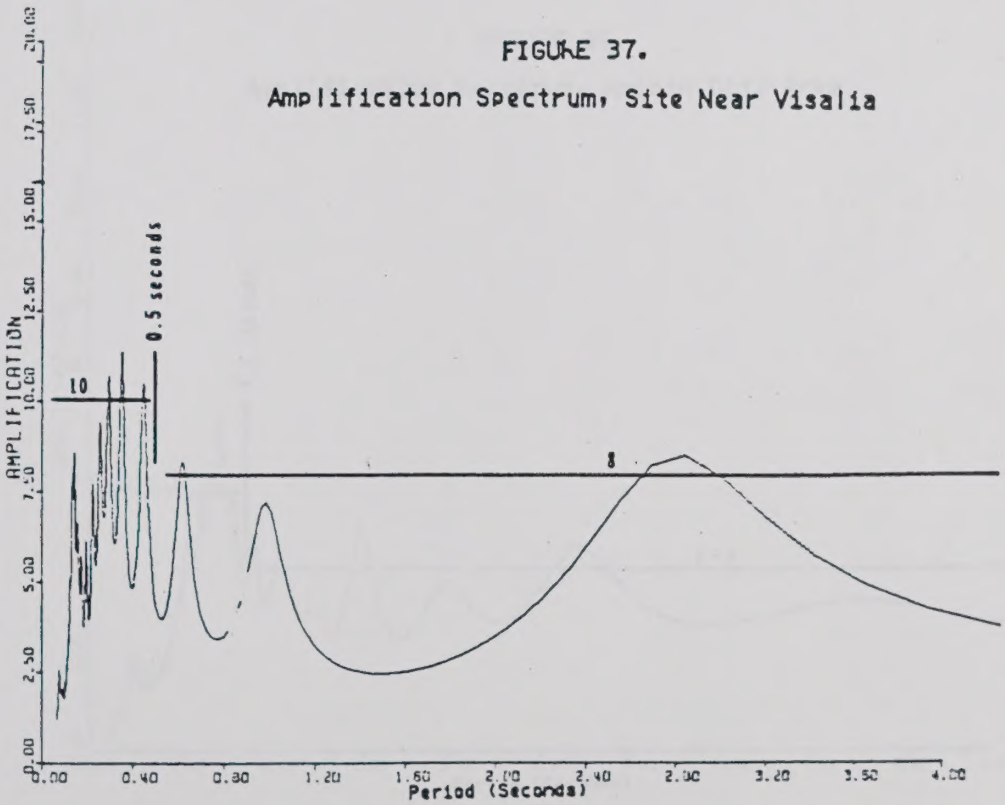


FIGURE 37.

Amplification Spectrum, Site Near Visalia



SOURCE: ENVICOM

FIGURE 38.

Amplification Spectrum, Cantua Creek

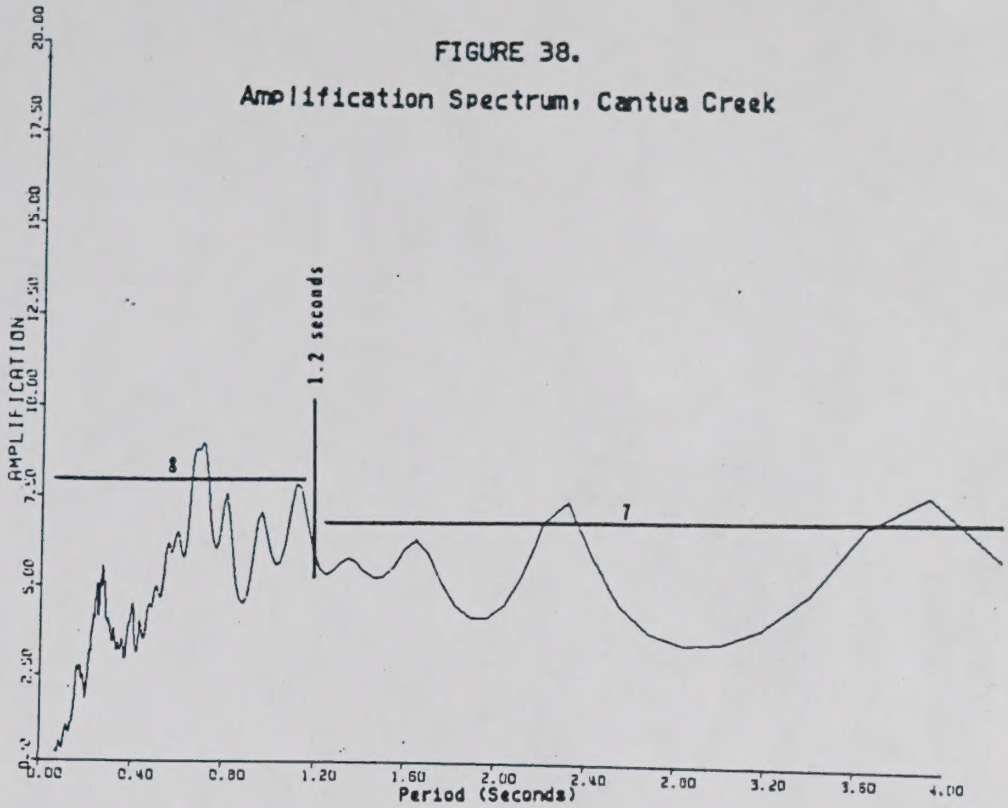
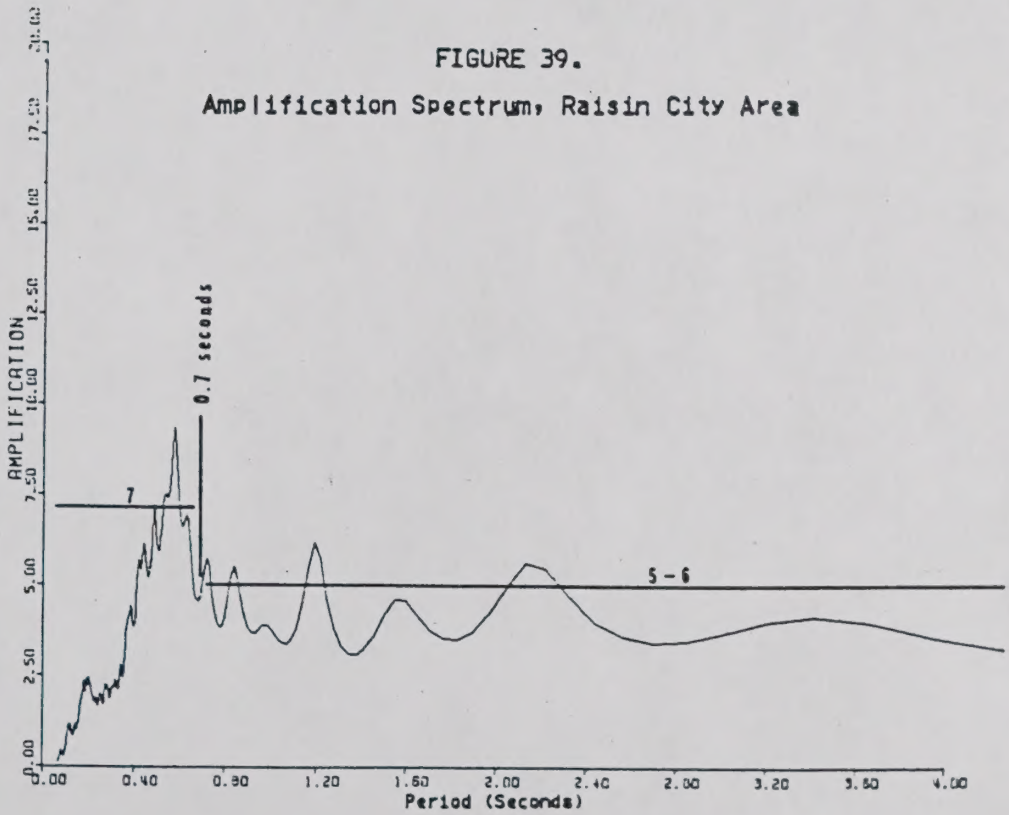


FIGURE 39.

Amplification Spectrum, Raisin City Area



SOURCE: ENVICOM

FIGURE 40.

Amplification Spectrum, Fresno Area

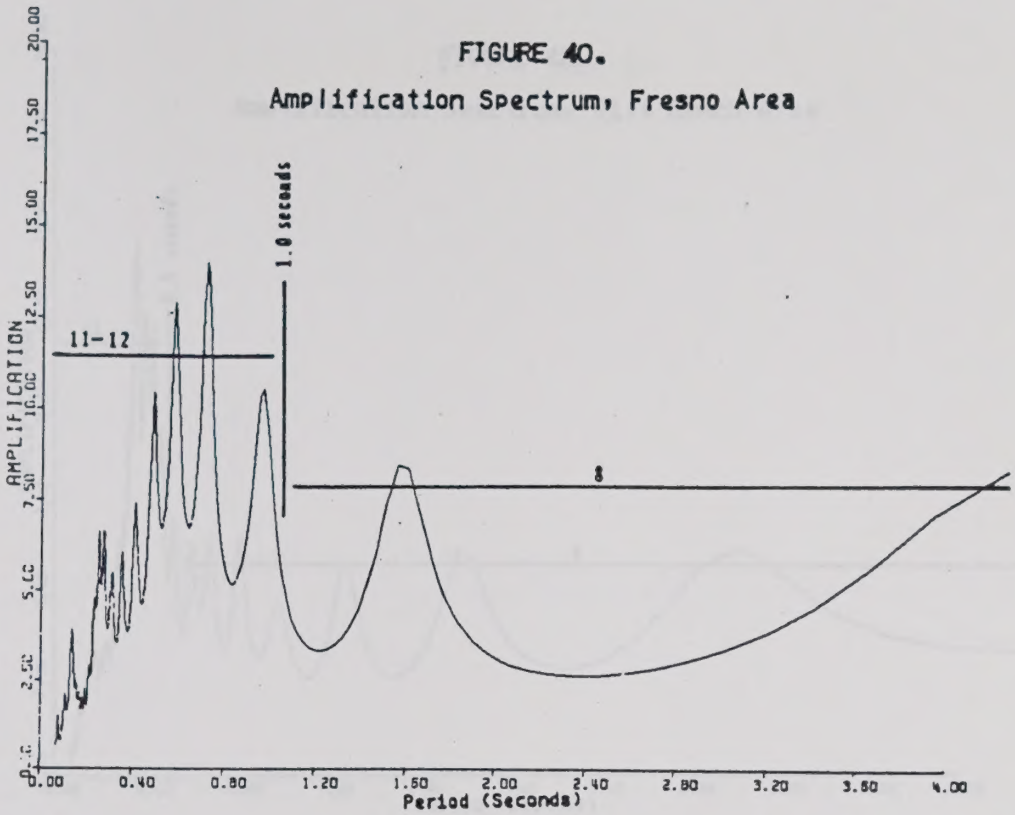
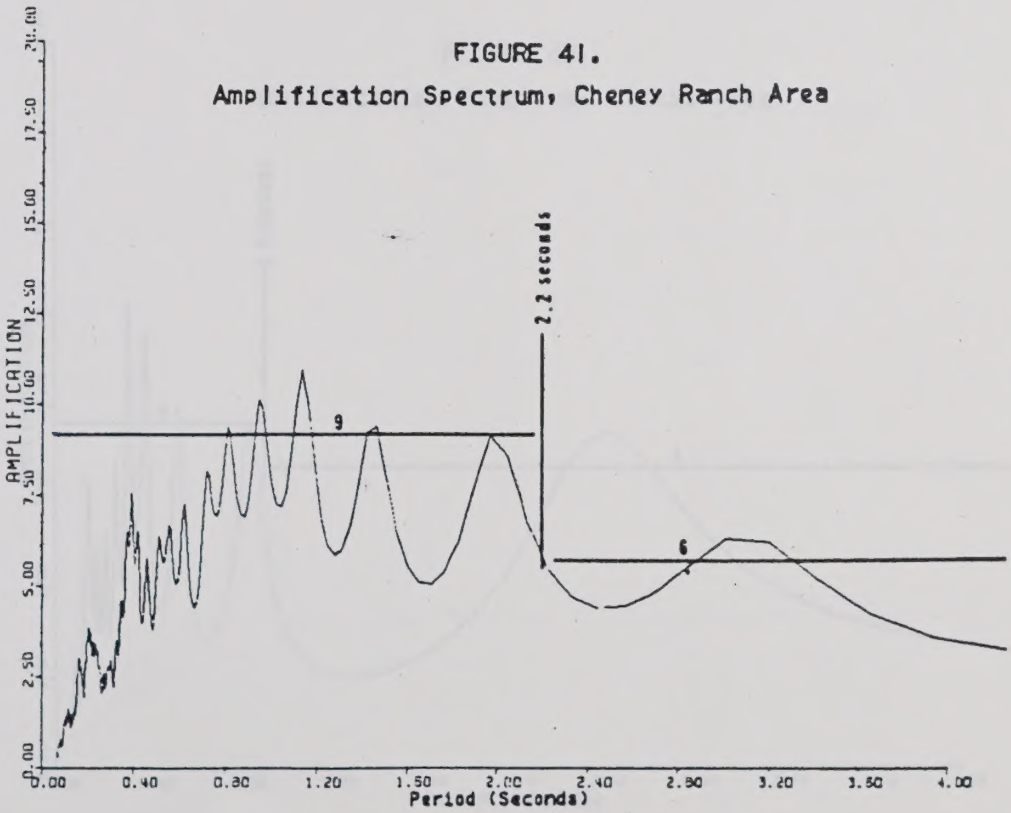


FIGURE 41.

Amplification Spectrum, Cheney Ranch Area



SOURCE: ENVICOM

FIGURE 42.

Amplification Spectrum, Gill Ranch Area

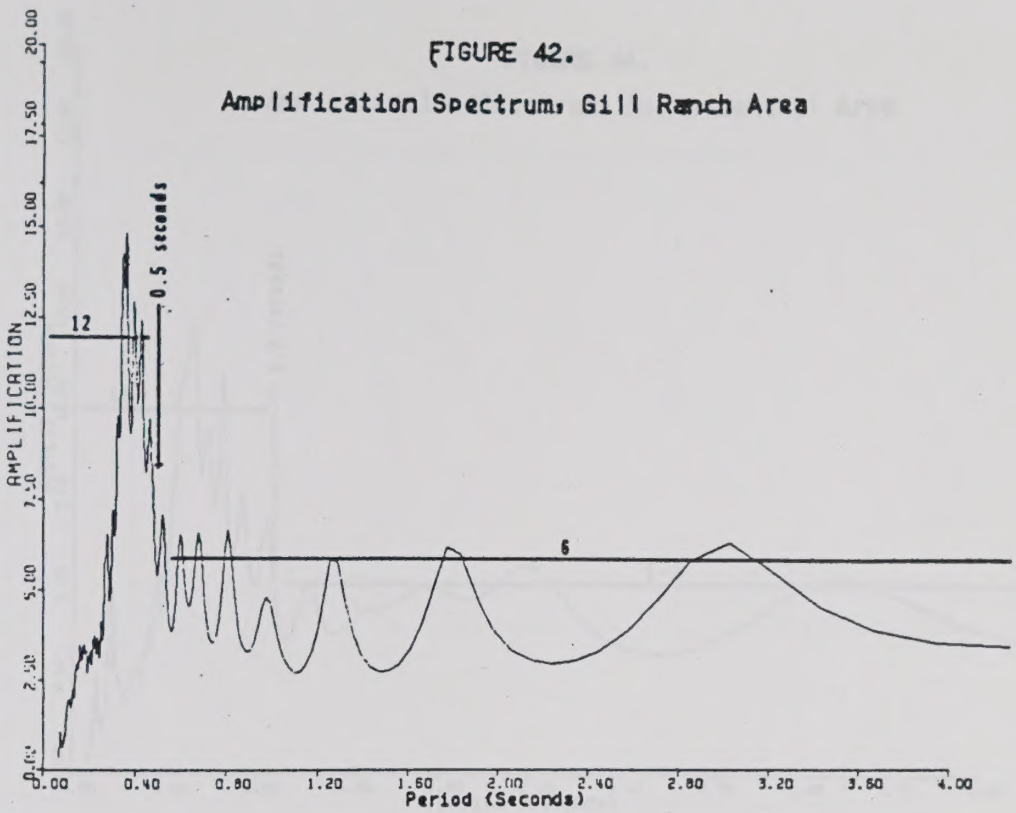
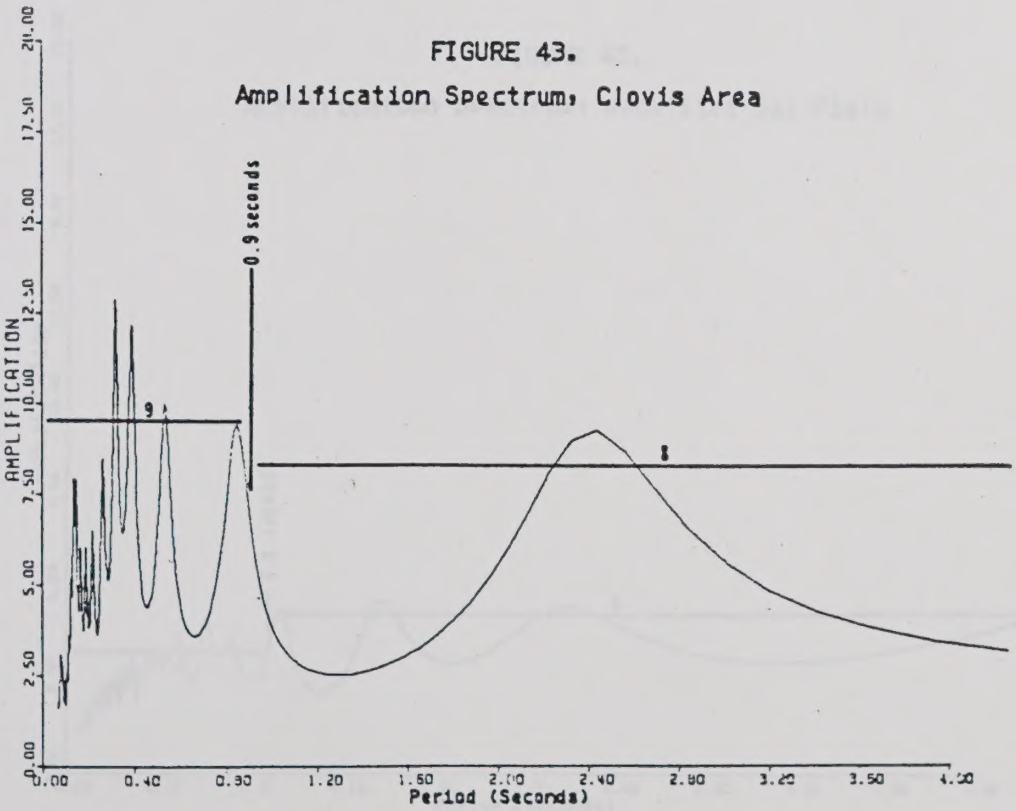


FIGURE 43.

Amplification Spectrum, Clovis Area



SOURCE: ENVICOM

FIGURE 44.

Amplification Spectrum, North-central Area

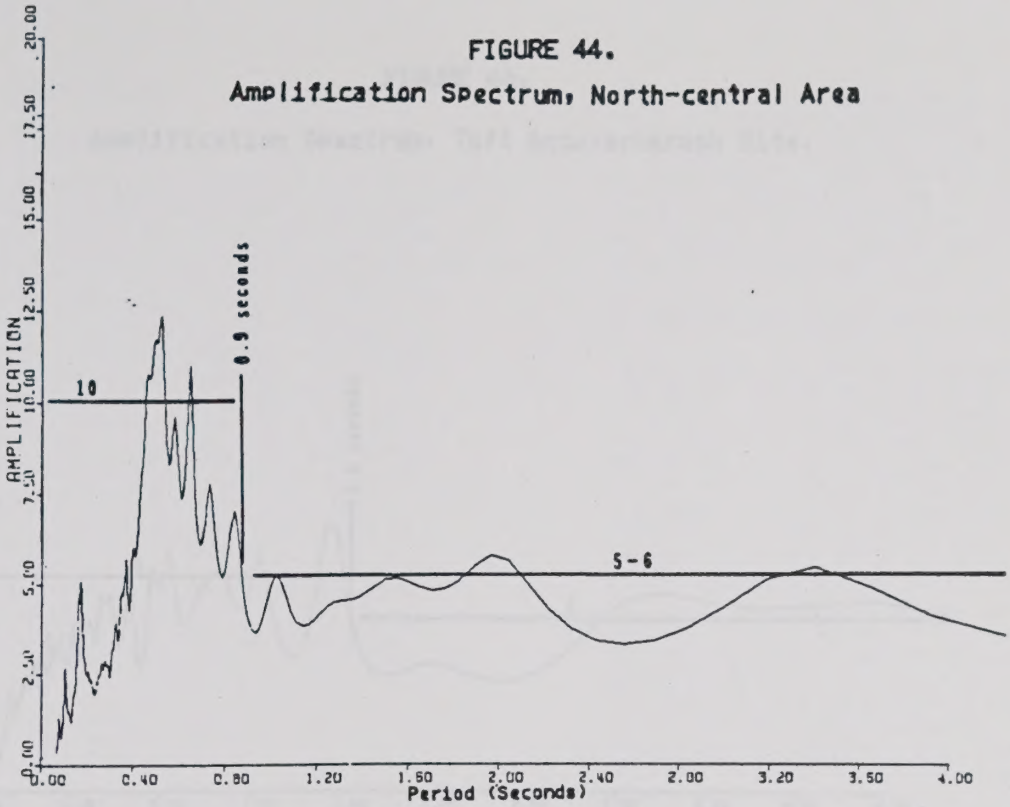
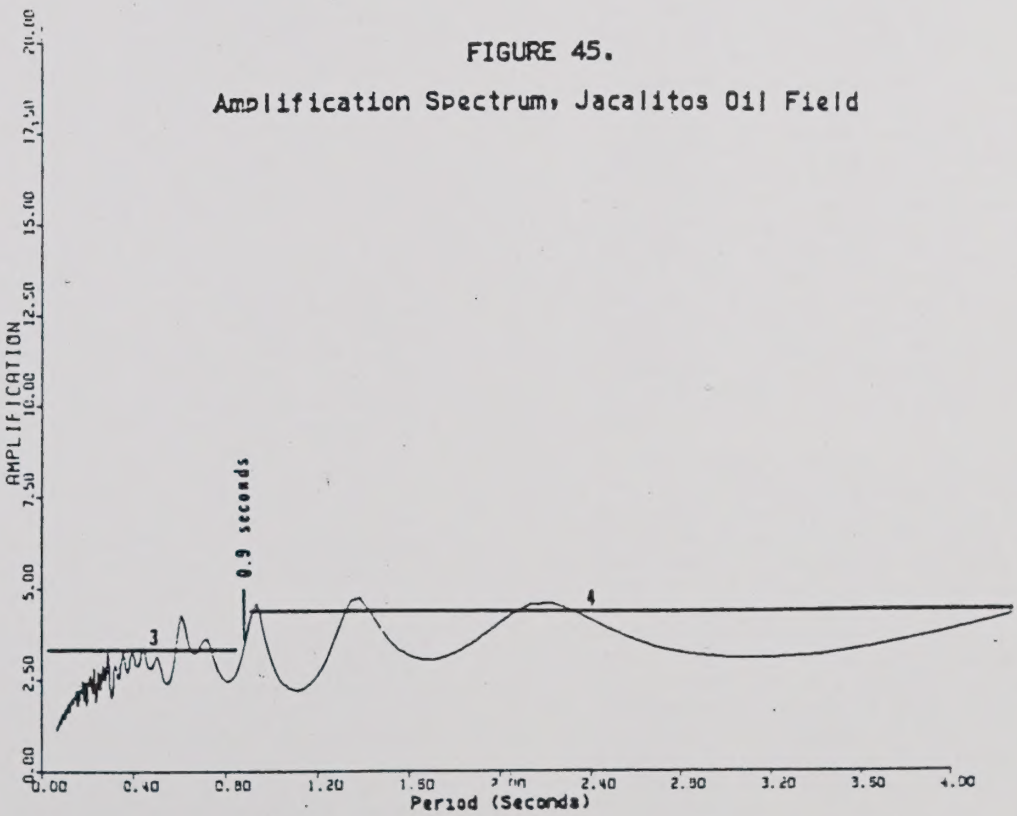


FIGURE 45.

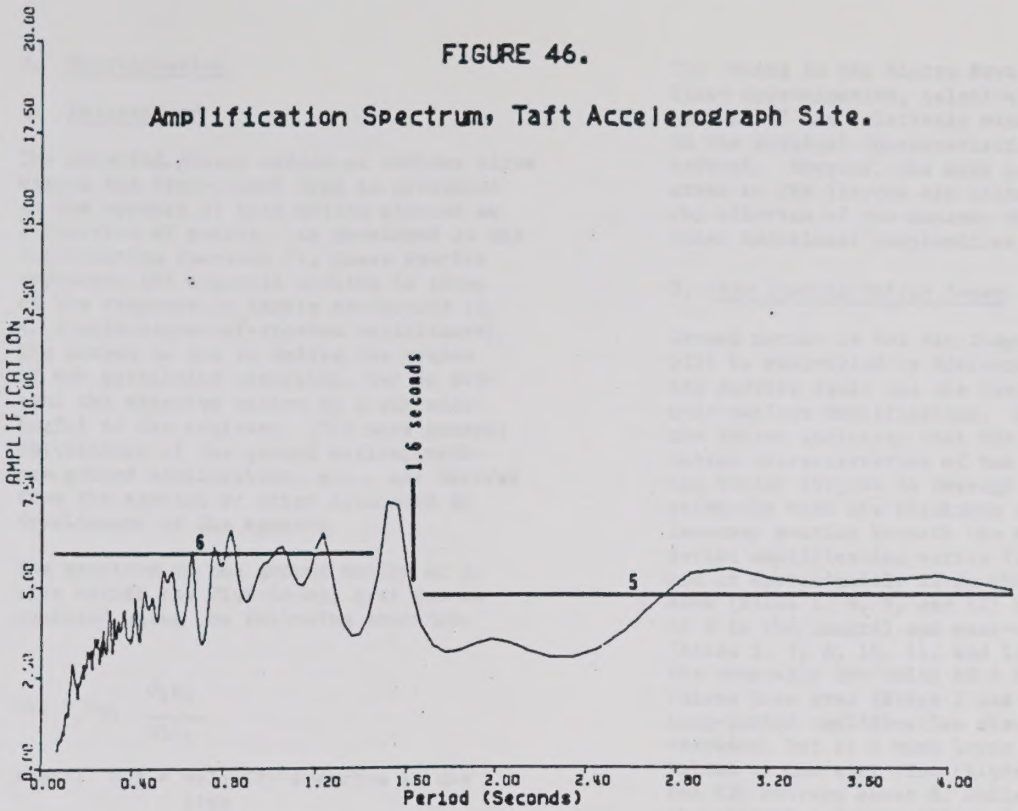
Amplification Spectrum, Jacalitos Oil Field



SOURCE: ENVICOM

FIGURE 46.

Amplification Spectrum, Taft Accelerograph Site.



SOURCE: ENVICOM

d. Microzonation

1. Methodology

The expected ground motion at various sites within the Five-County area is presented as the spectra of this motion plotted as a function of period. As developed in the Introduction (section 7), these spectra represent the expected shaking in terms of the response of simple structures (i. e. single-degree-of-freedom oscillators). The intent is not to define the motion of any particular structure, but to present the expected motion in a way meaningful to the engineer. The more general descriptors of the ground motion, maximum ground acceleration, etc., are derived from the spectra or other data used in development of the spectra.

The spectrum of the ground motion at a site within the Five-County area can be computed using the following equation:

$$S_{V2} = S_{V1} \frac{d_1 A_2}{d_2 A_1}$$

where: S_{V2} = velocity spectrum at the site
S_{V1} = velocity spectrum of the "type earthquake,"
d_1 = distance, in bedrock, of the "type earthquake" record from the earthquake source,
d_2 = distance in bedrock, of the site from the earthquake source,
A_1 = amplification spectrum of site of the "type earthquake" record, and
A_2 = amplification spectrum of the site.

In the equation above, the distance factors are simplified from a more complex equation assuming cylindrical spreading from a line source and negligible damping in bedrock (granite or Franciscan metamorphic rocks). The spectral relationships are based on linear system theory (Duke et al, 1970) valid for the Fourier spectra of the ground motion. Their application to the response spectra of the ground motion at values of 0-10% of critical damping is an approximation considered adequate for the generalization necessary in zoning an area the size of the Five-County area.

Discussion of the microzoning of the area is divided into three sections based on the distinctly different near-surface amplification characteristics in the major three physiographic provinces. The zoning in San Joaquin Valley and the western coastal mountains is the most complex because thick layered sequences are involved, and most of the people live there.

The zoning in the Sierra Nevada is, to a first approximation, relatively simple because of the relatively minor changes in the physical characteristics of the bedrock. However, the more populated areas in the Sierras are often located on the alluvium of the meadows which introduces additional complexities.

2. San Joaquin Valley Zones

Ground motion in the San Joaquin Valley will be controlled by distance to the San Andreas fault and the variation in near-surface amplification. Analysis of the latter indicates that the amplification characteristics of the 13 sites in the Valley (Figure 34 through 46) vary primarily with the thickness of the sedimentary section beneath the site. Short-period amplification varies from an average of approximately 12 in the east valley area (Sites 1, 6, 9, and 12) to an average of 8 in the central and west-valley areas (Sites 5, 7, 8, 10, 11, and 13), and has the unusually low value of 4 in the Tulare Lake area (Sites 2 and 3). The long-period amplification also decreases westward, but at a much lower rate. Values on the east side (Sites 1, 6, 9, and 12) average about 8, while those in the central and west (Sites 2, 3, 4, 5, 7, 8, 10, 11 and 13) average about 6.

The averaging of the amplification characteristics as discussed above is a necessary step in applying the results of a detailed analysis of a few sites to the evaluation of a large area. In this case, comparison of the amplification spectra derived by the modeling process with the characteristics of the models indicates that the major variations in amplification are controlled by variations in the thickness of the sedimentary section. Since the effects of shallow variations in velocity are minor, the results obtained from the individual sites can be extrapolated laterally on the basis of variations in the sedimentary section as determined from wells drilled for oil, and to a lesser extent for water, in the area.

In this system of analysis, the individual sites provide the detailed control from which the larger area can be interpreted from more readily available data. Thus, the distribution of the seismic zones is the result of variations in subsurface geologic conditions and the distance to the source of the expected earthquake, while the engineering characteristics of each zone are based on the numerical results of the detailed analysis of the sites. The results of this system of analysis are compared to experienced intensities of shaking in a later section of this report.

The ground-motion spectra for typical areas in the Valley proper and the Coalinga-Kettleman Plain area have been computed using the equation developed in the previous section and the variation in near-surface amplification discussed above. The "type earthquake" (S_{V1} in equation) is a smoothed envelope (Figure 48) of the spectra of the two horizontal components of the Type A ground motion of Jennings, Housner and Tsai, discussed previously. Distance to the "recorded" ground motion (d_1 in equation) is assumed to be 10 miles for reasons discussed previously. The near-surface amplification of the site of the "type earthquake" (A_1 in equation) is assumed to be approximately the same as that for Taft (Figure 48), which was generated using the model of Lastrico (1970). The distance to the causative fault (d_2 in equation) and the generalized area amplification characteristics (A_2 in equation) are summarized in Table 25. The applicable ranges of period shown in the table are approximate, and some smoothing is necessary in deriving the response spectra shown in Figures 49 through 55.

Comparison of the seven spectra indicates that the first four are very similar and can be combined into one zone, designated V1. The similarity of these areas is due to the decrease in near-surface amplification toward the southwest, which is the same direction that ground shaking would normally increase due to decreasing distance to the causative fault. The spectrum for the Tulare Lake area, zone V2, is similar to those of zone V1, but is lower in the short-period range because of the usually low amplification of this range.

Zones V3 and V4 are based on the Cantua Creek and Coalinga-Kettleman Plain spectra. Both zones have lower amplification than zones to the northeast, but it is not sufficient to outweigh the decrease in distance to the San Andreas fault.

The boundaries of the four valley zones are somewhat arbitrary. The low short-period amplification of zone V2 appears to be related in part to the old lake beds, and the boundary of the zone is defined on this basis. The boundary between zones V3 and V2 is gradational. It is placed further to the northeast in the Mendota-Firebaugh area because of the higher amplification factors at sites 10, 11 and 13 as opposed to those at sites 7 and 8. The boundary between zones V3 and V4 is based primarily on distance to the San Andreas fault, and is also gradational. The resulting valley zones are shown on Plate I, and the general characteristics of the ground motion and a typical spectrum for each zone are shown on Table 26.

3. Coastal Mountain Zones

The coastal mountains were zoned using a procedure very similar to that used in zoning the San Joaquin Valley except that preliminary zones, based on variation in rock types, were defined as a first step. Those zones were defined as follows:

1. Kettleman Trend -- pre-Eocene rocks along the east flank of the mountains in northwest Fresno County, and in the Kettleman Hills.

   Joaquin Ridge -- Eocene and older rocks in northwest Fresno County.

2. Jacalitos Trend -- Pliocene rocks along the east flank of the mountains in southwest Fresno County, and older rocks toward the west.

   Wortham Valley -- Pliocene and some older rocks along the southwest border of Fresno and Kings County.

The objective in defining the preliminary zones as described was to group rocks of similar age and at similar distances from the San Andreas with older rocks having lower near-surface amplification located closer to the fault.

The distance and amplification characteristics of the four zones are given in Table 27, and the resulting response spectra are shown in Figures 56 through 59.

Comparison of the four spectra indicates that those for the Kettleman Trend and Joaquin Ridge can be combined into one zone designated C1. Also, the spectra for the Jacalitos Trend and Wortham Valley are sufficiently similar to be combined as zone C2. The combined zones and the final zone boundaries are shown on Plate I. The general characteristics of the ground motion and a typical spectrum for each zone are shown in Table 26.

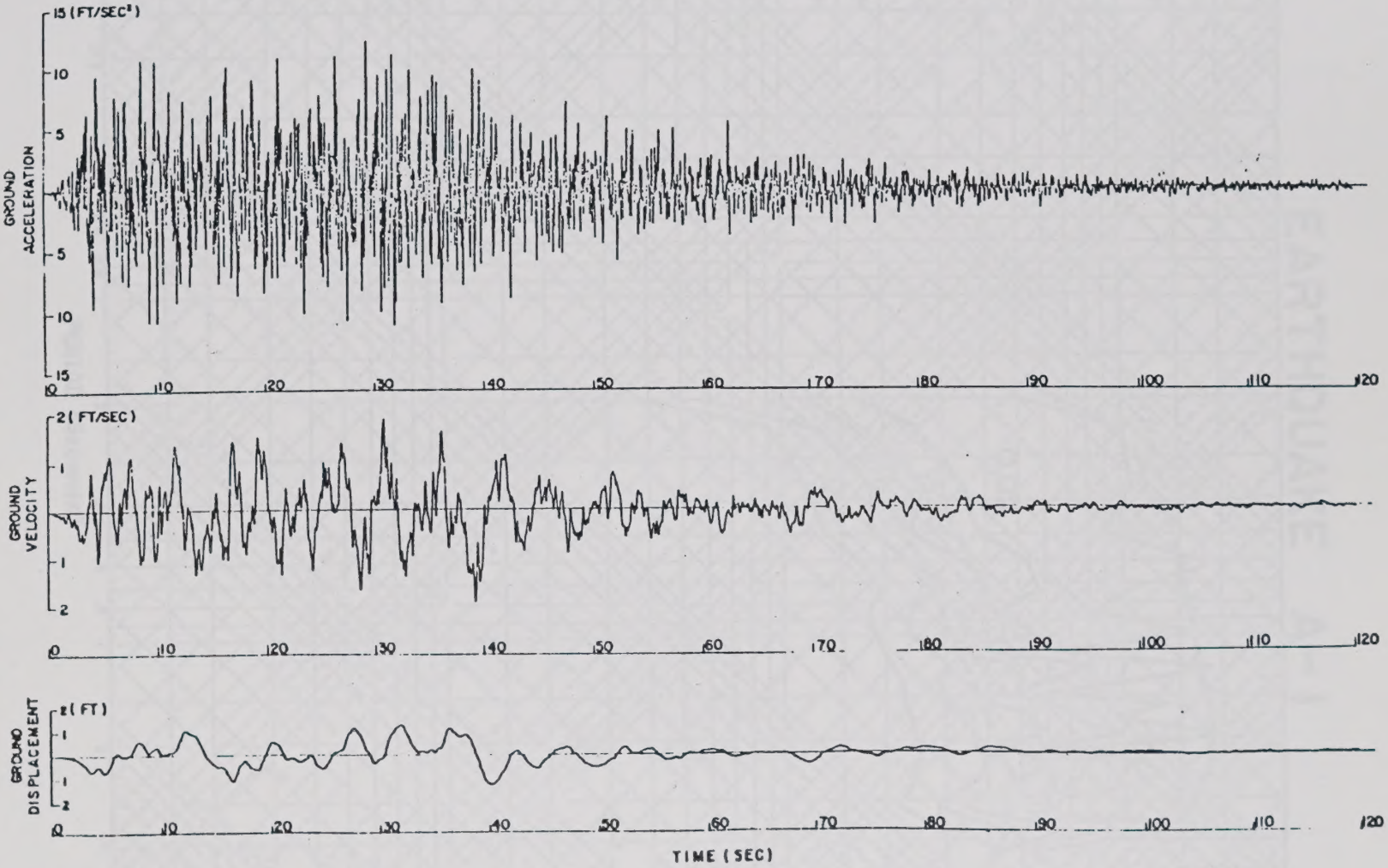


FIGURE 47. EARTHQUAKE A-I

Acceleration, Velocity and Displacement for Earthquake A-I

From Jennings, Housner & Tsai, 1968

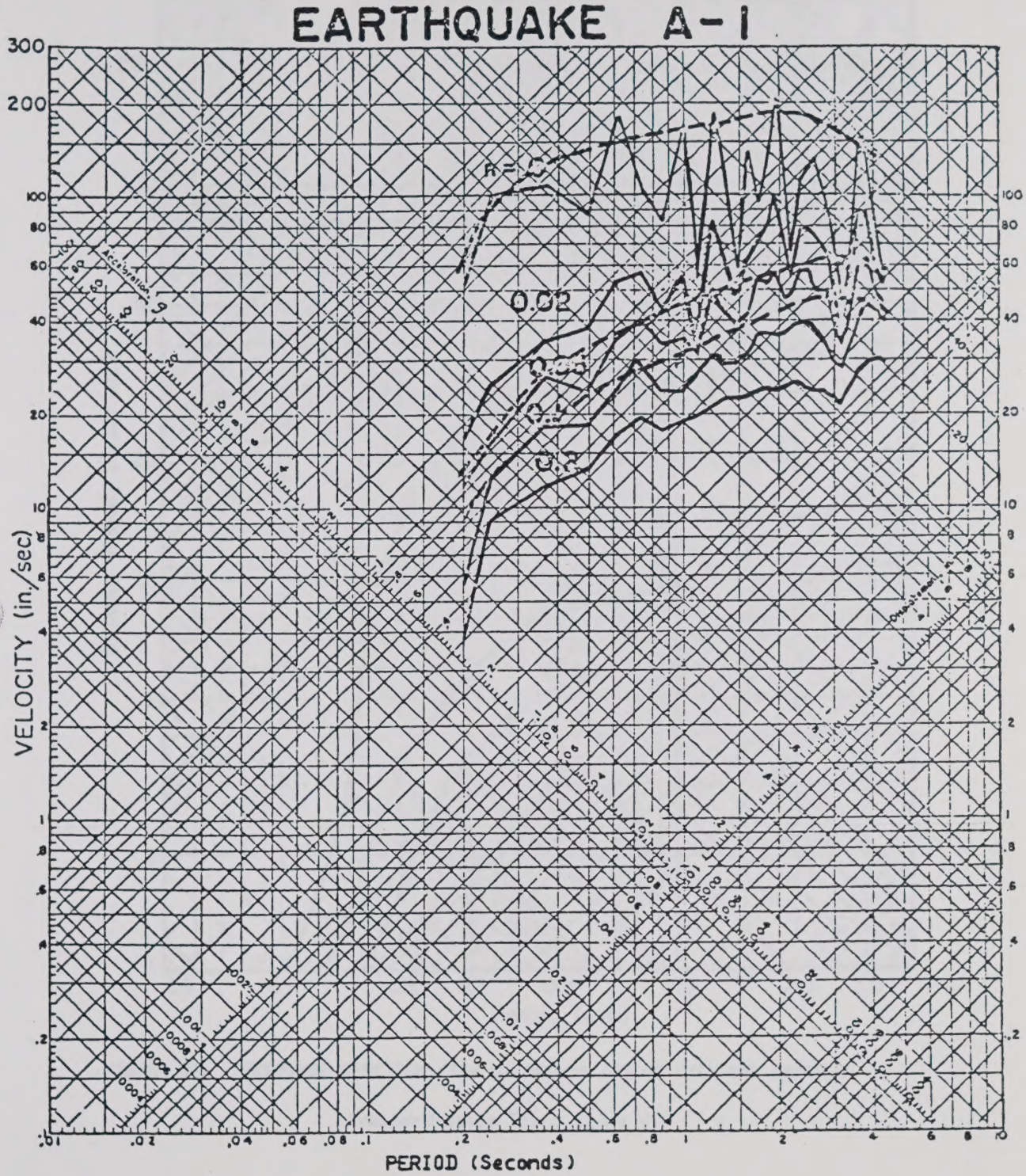


FIGURE 48. Tripartite logarithmic plot of spectra for earthquake A-1 showing smoothed envelopes for 0%, 5%, and 10% critical damping. Based on Jennings, Housner, & Tsai, 1968.

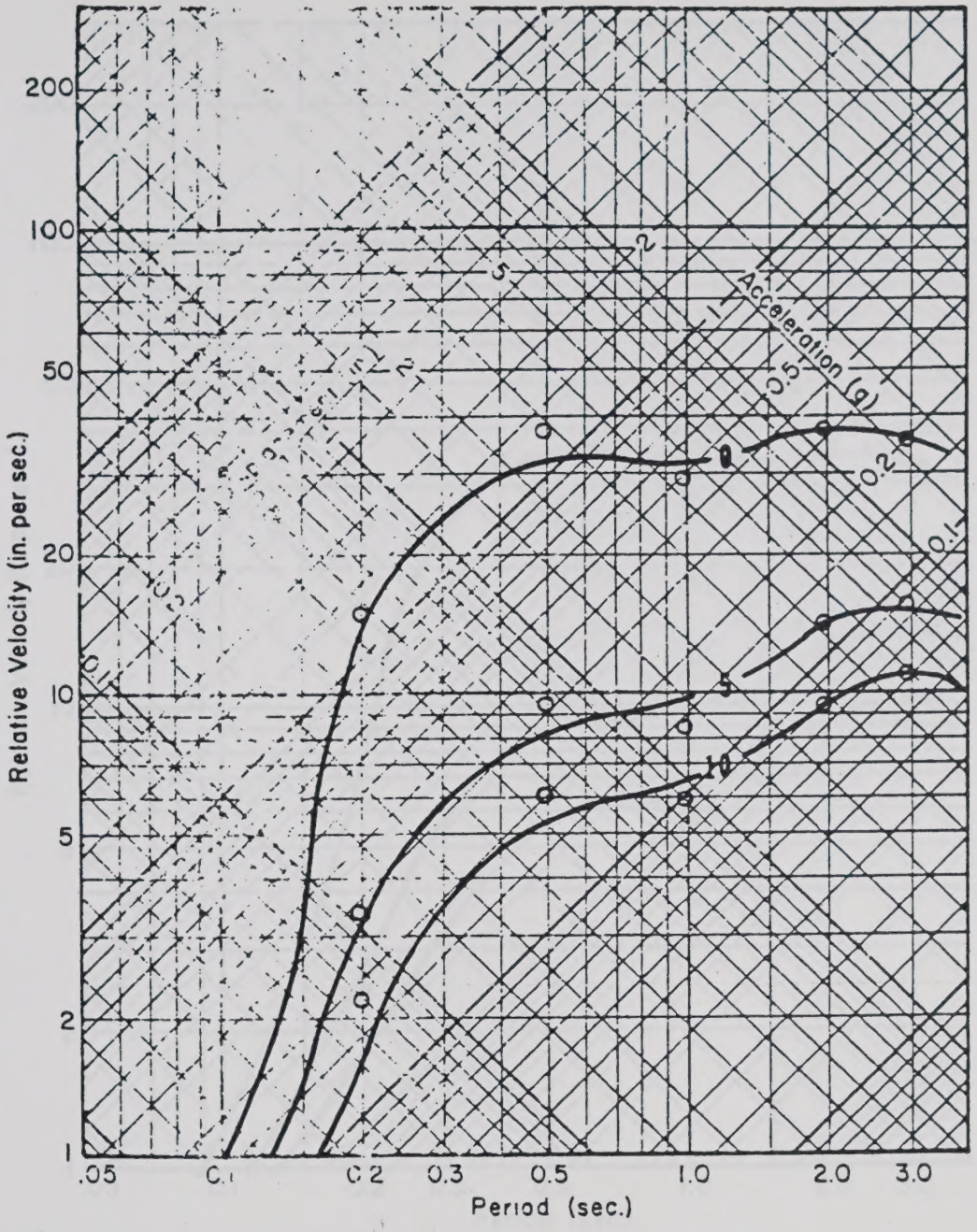


FIGURE 49. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Fresno-Visalia Trend (Zone VI)

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

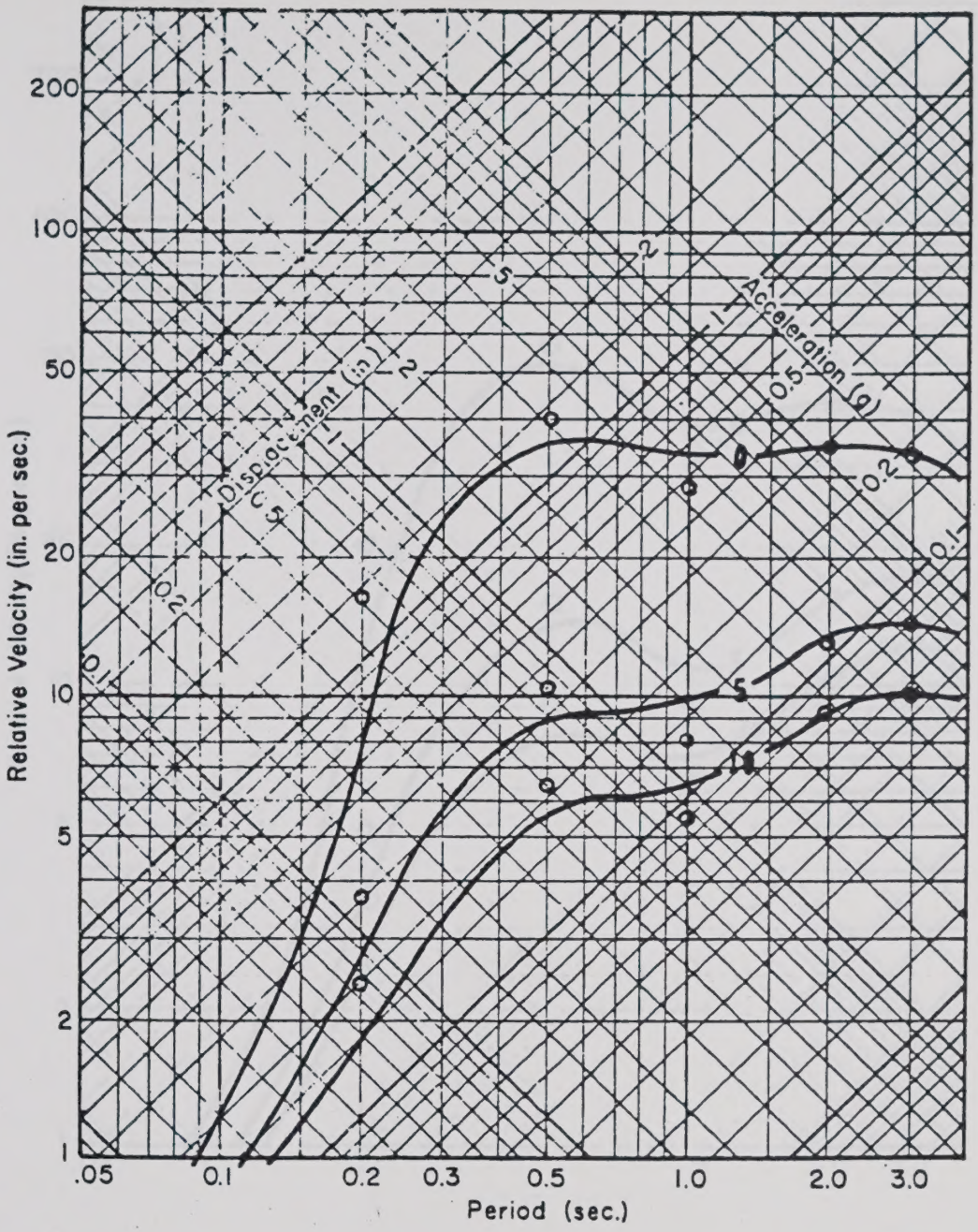


FIGURE 50. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Hanford Area (Zone VI)

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

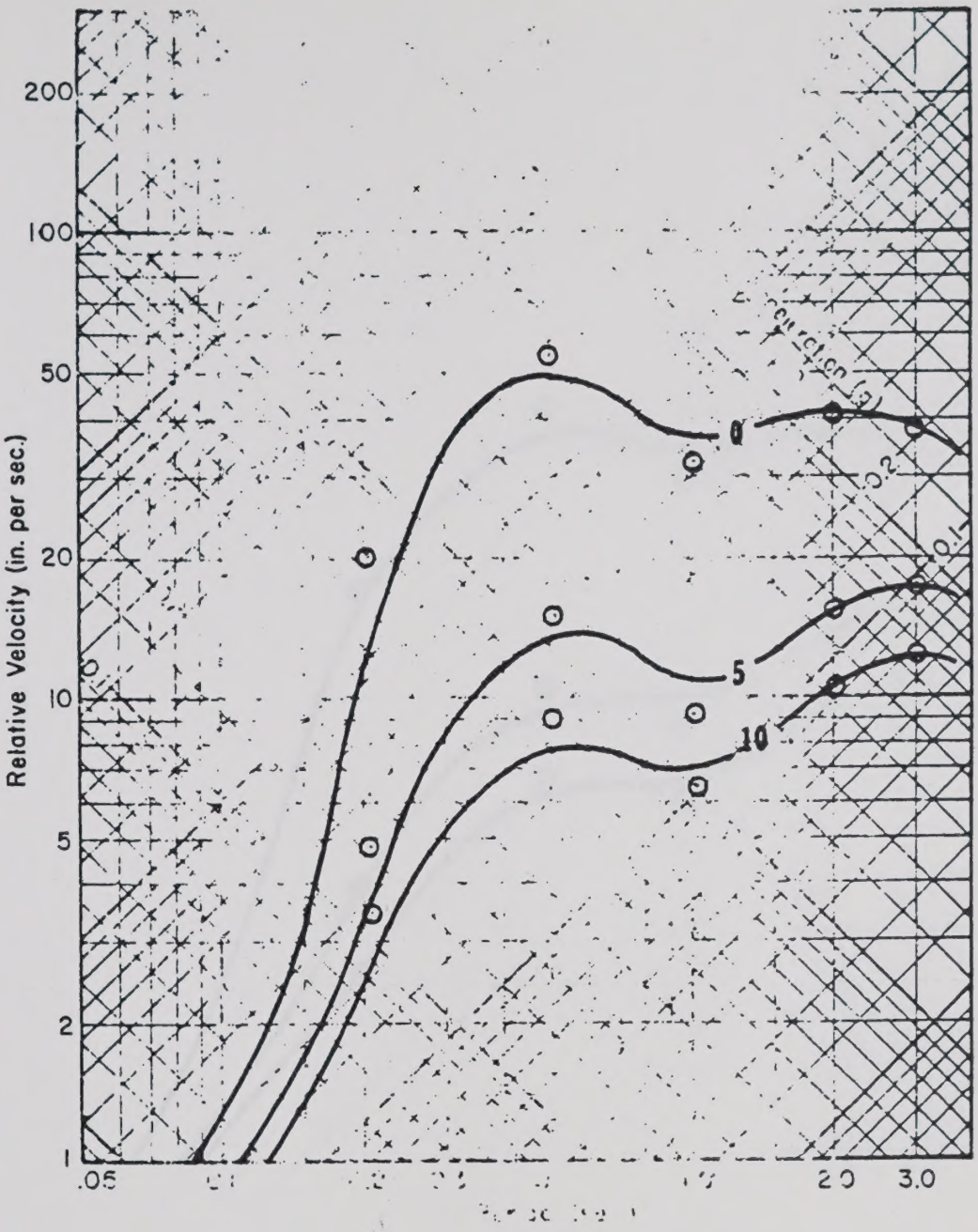


FIGURE 51. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

South-central Tulare County (Zone VI)

GRAPHICS BY TULARE

SOURCE: ENVICOM

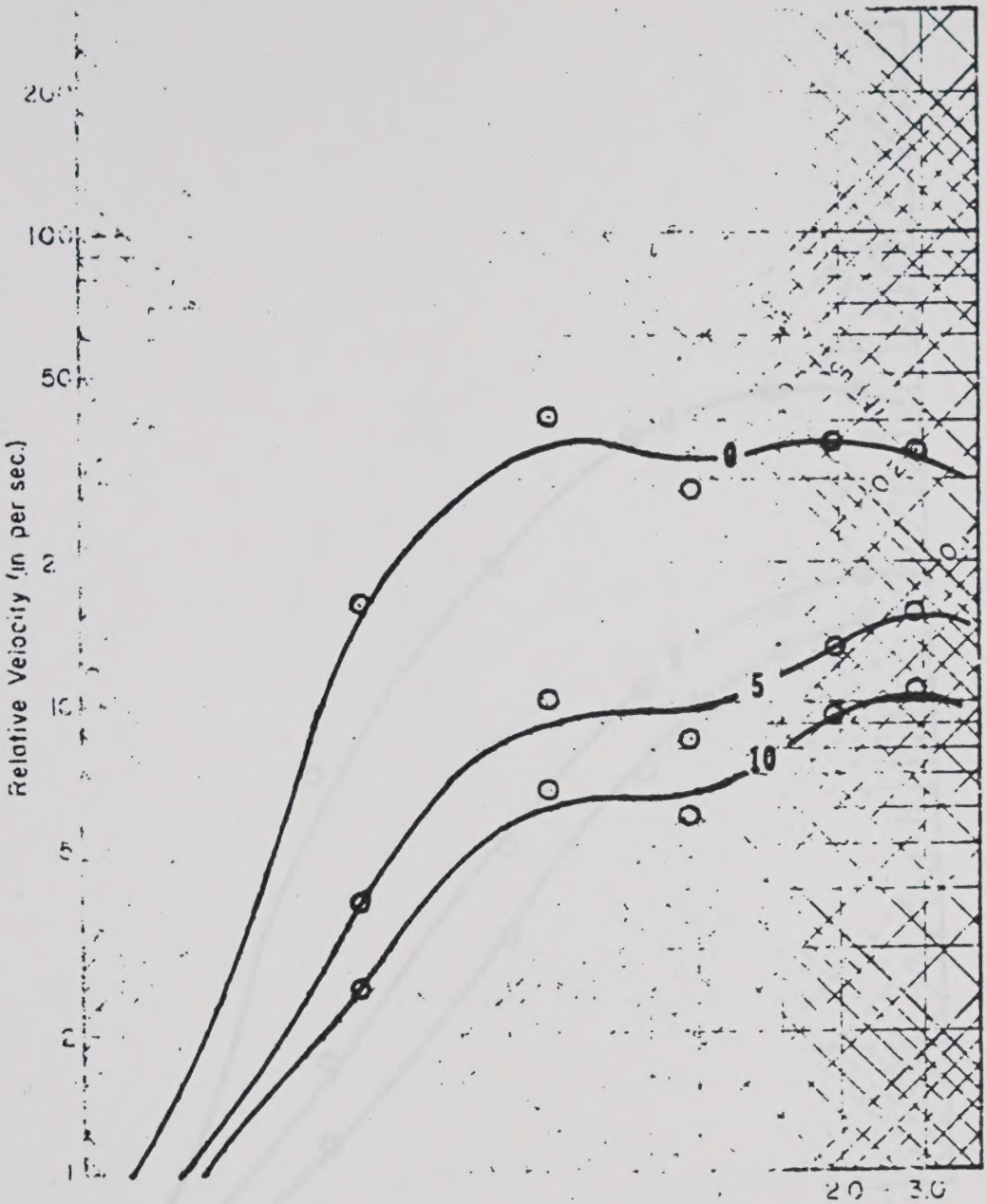


FIGURE 52. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping,

North-central Area (Zone VI)

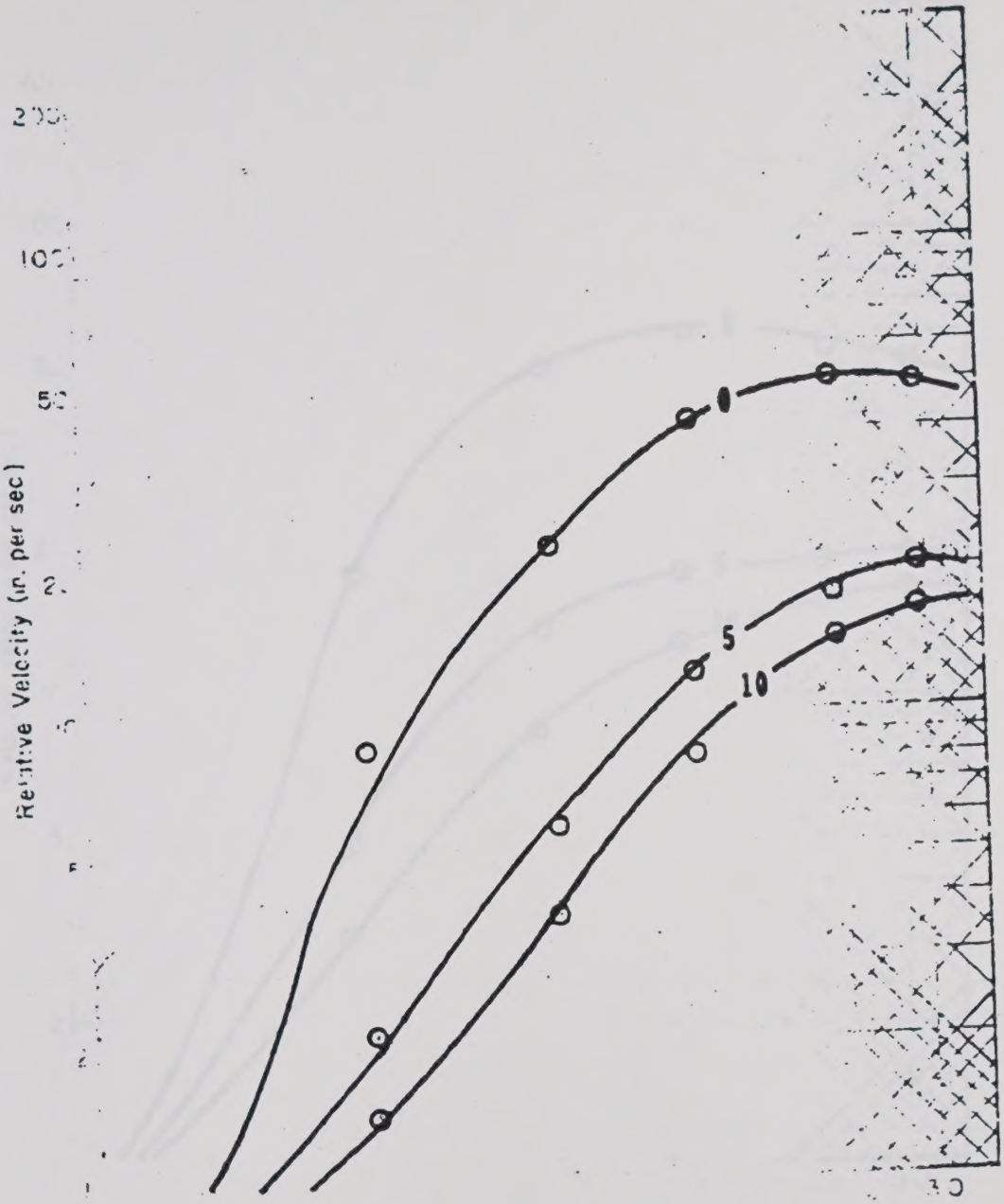


FIGURE 53. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Tulare Lake Area (Zone V2)

GRAPHIC

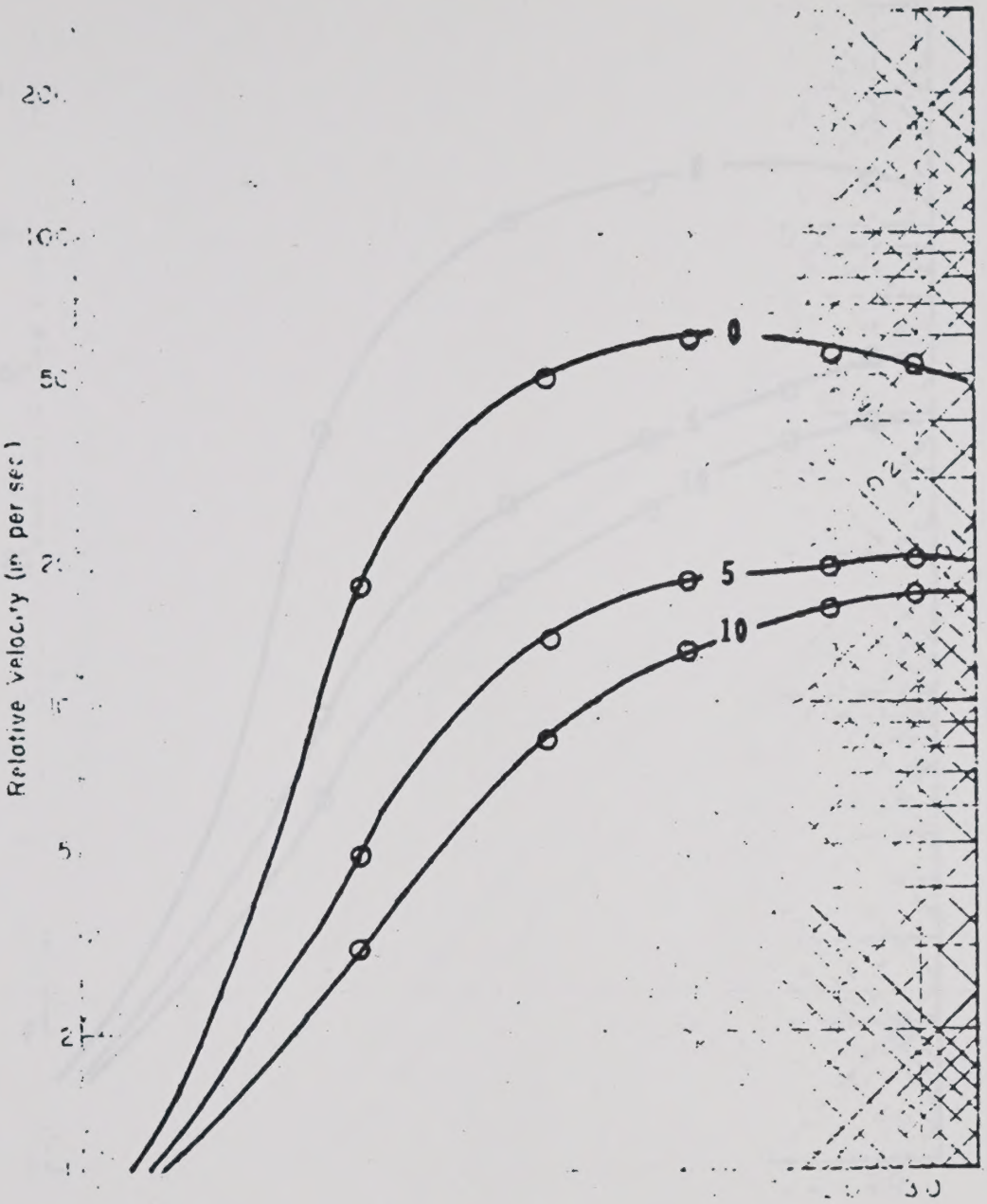


FIGURE 54. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Cantua Trend (Zone V3)

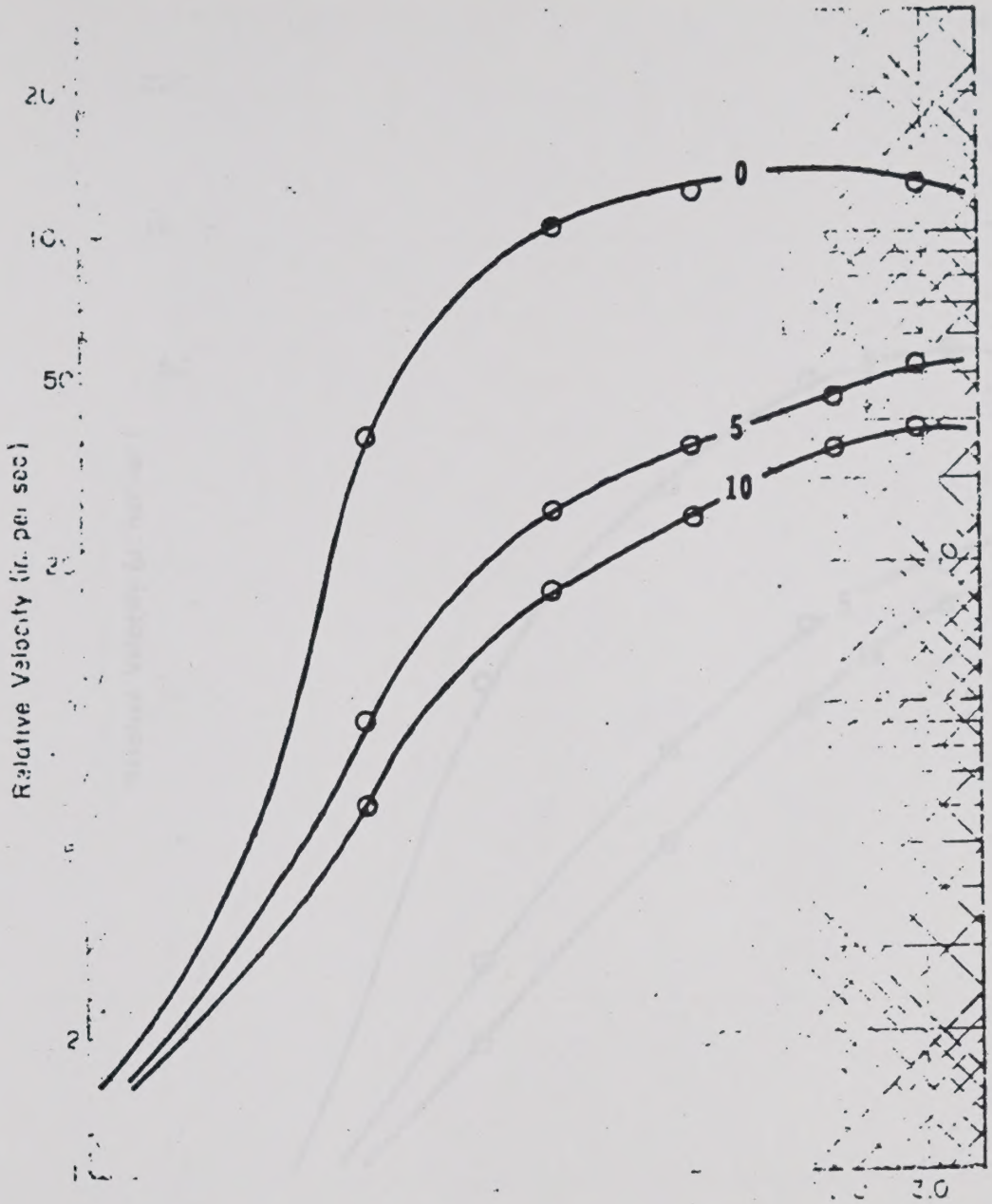


FIGURE 55. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Coalinga-Kettleman Plain (Zone V4)

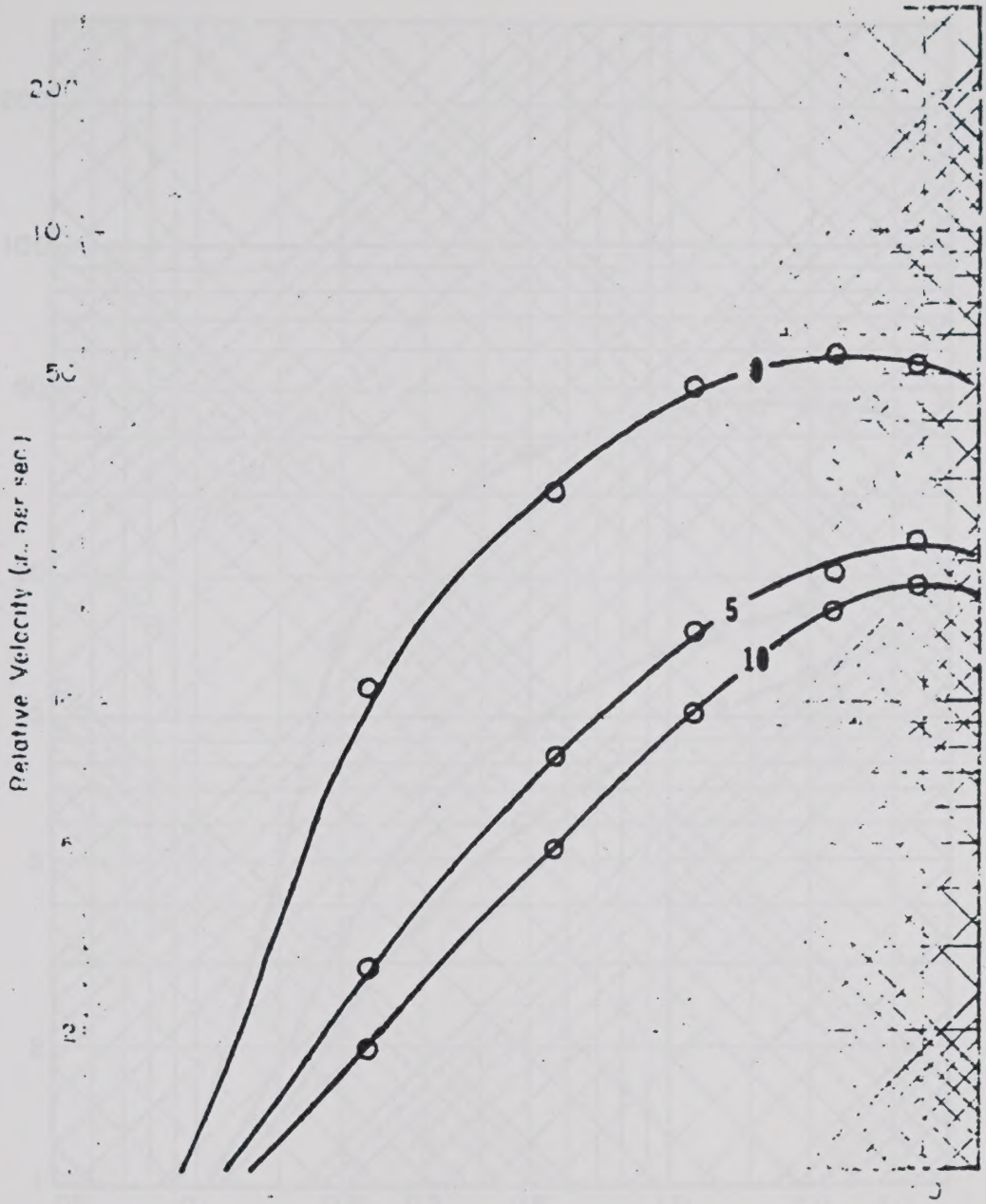


FIGURE 56. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Kettleman Trend (Zone C1)

GRAPHIC COPY

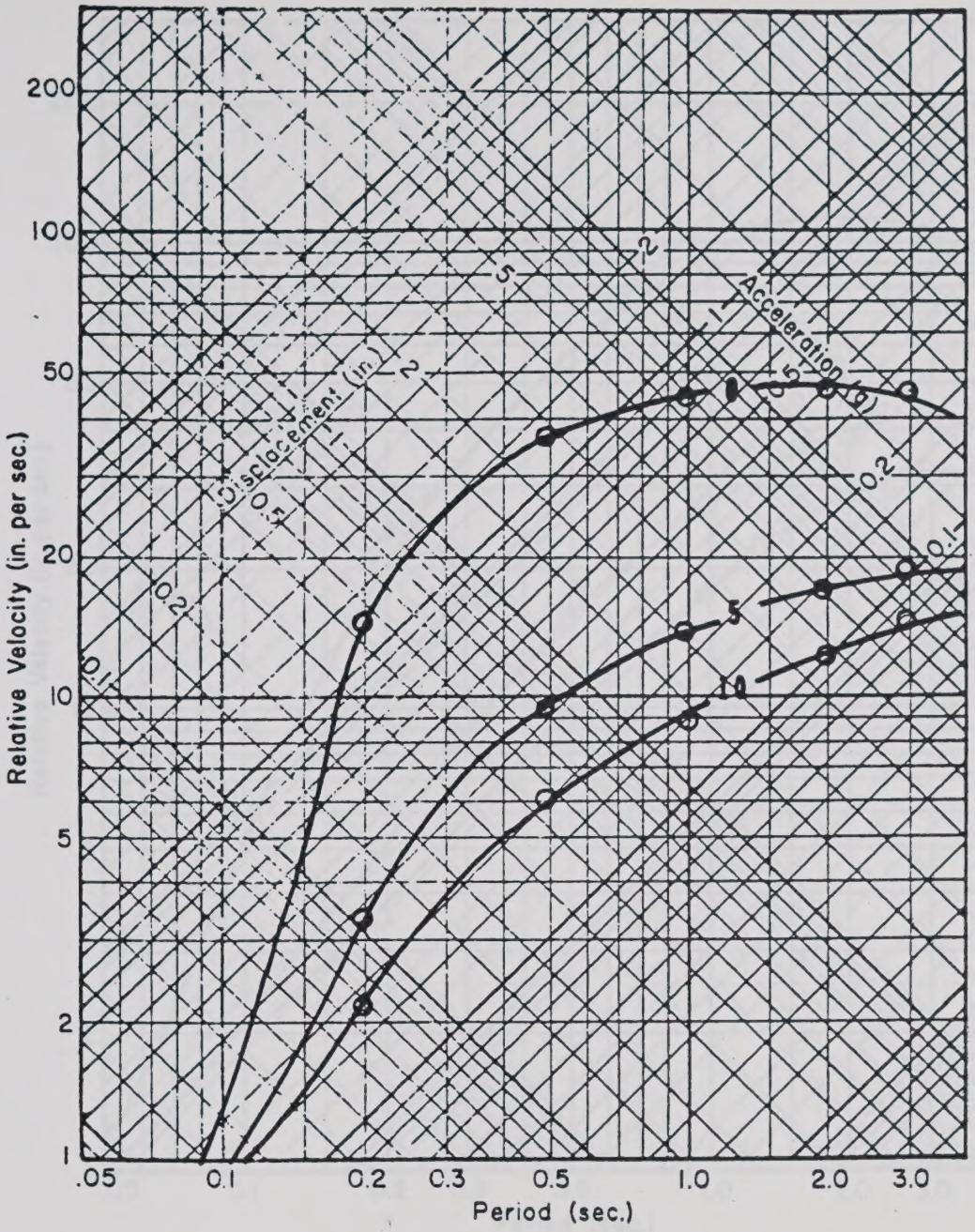


FIGURE 57. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Joaquin Ridge (Zone C1)

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

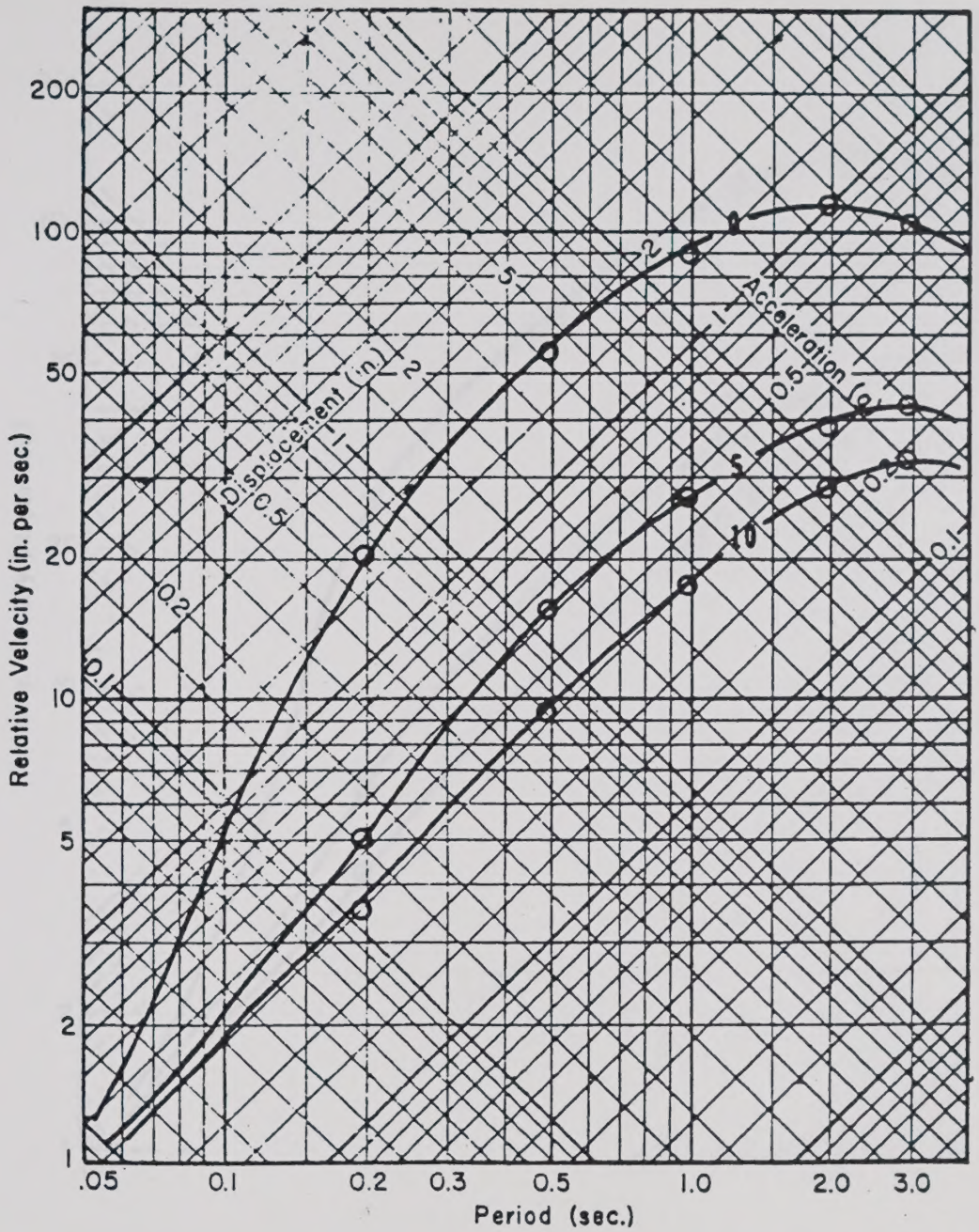


FIGURE 58. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Jacalitos Trend (Zone C2)

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

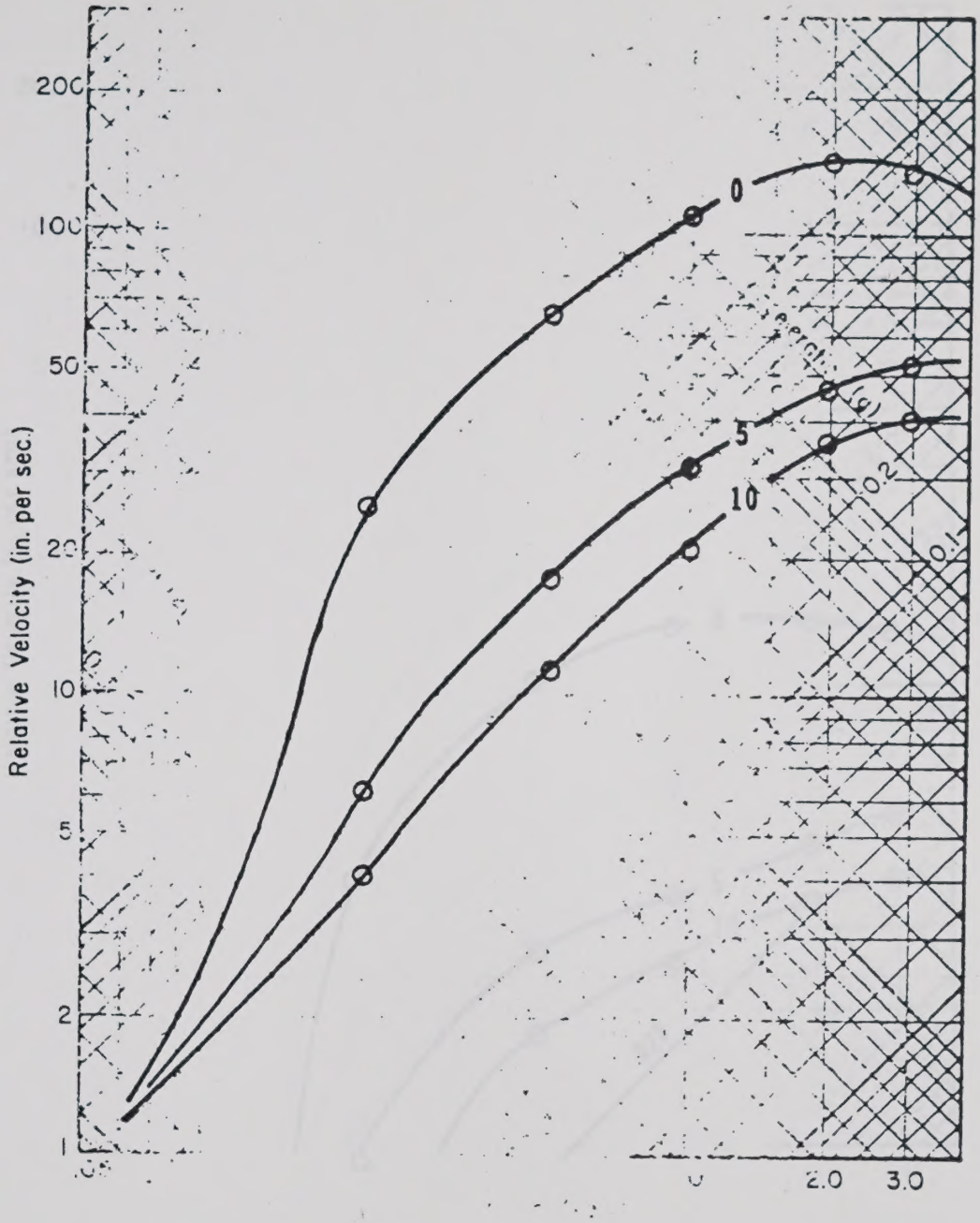


FIGURE 59. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Wortham Valley (Zone C2)

GRAPHICS BY

SOURCE: ENVICOM

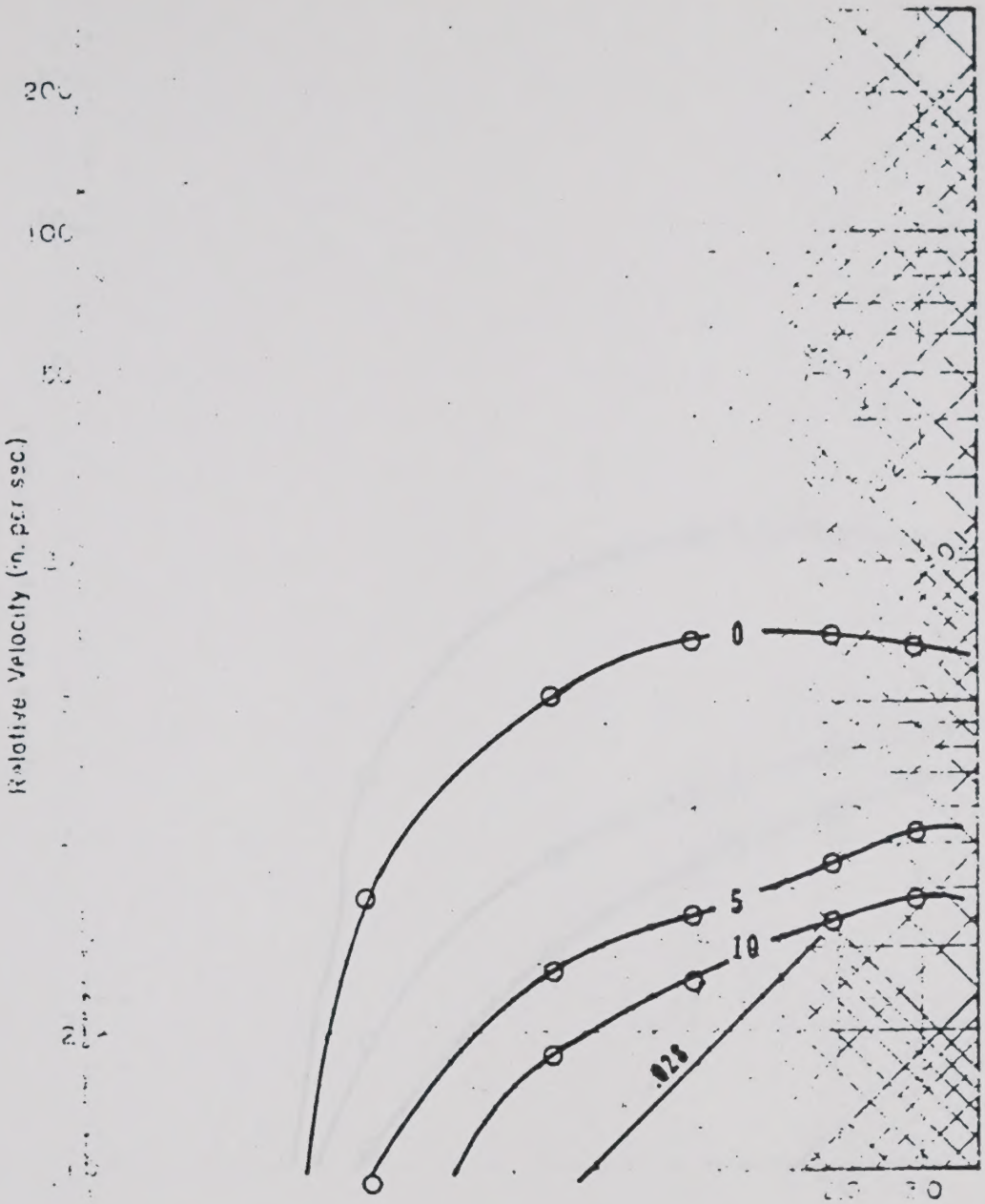


FIGURE 60. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Bedrock Sites (Zone S1)

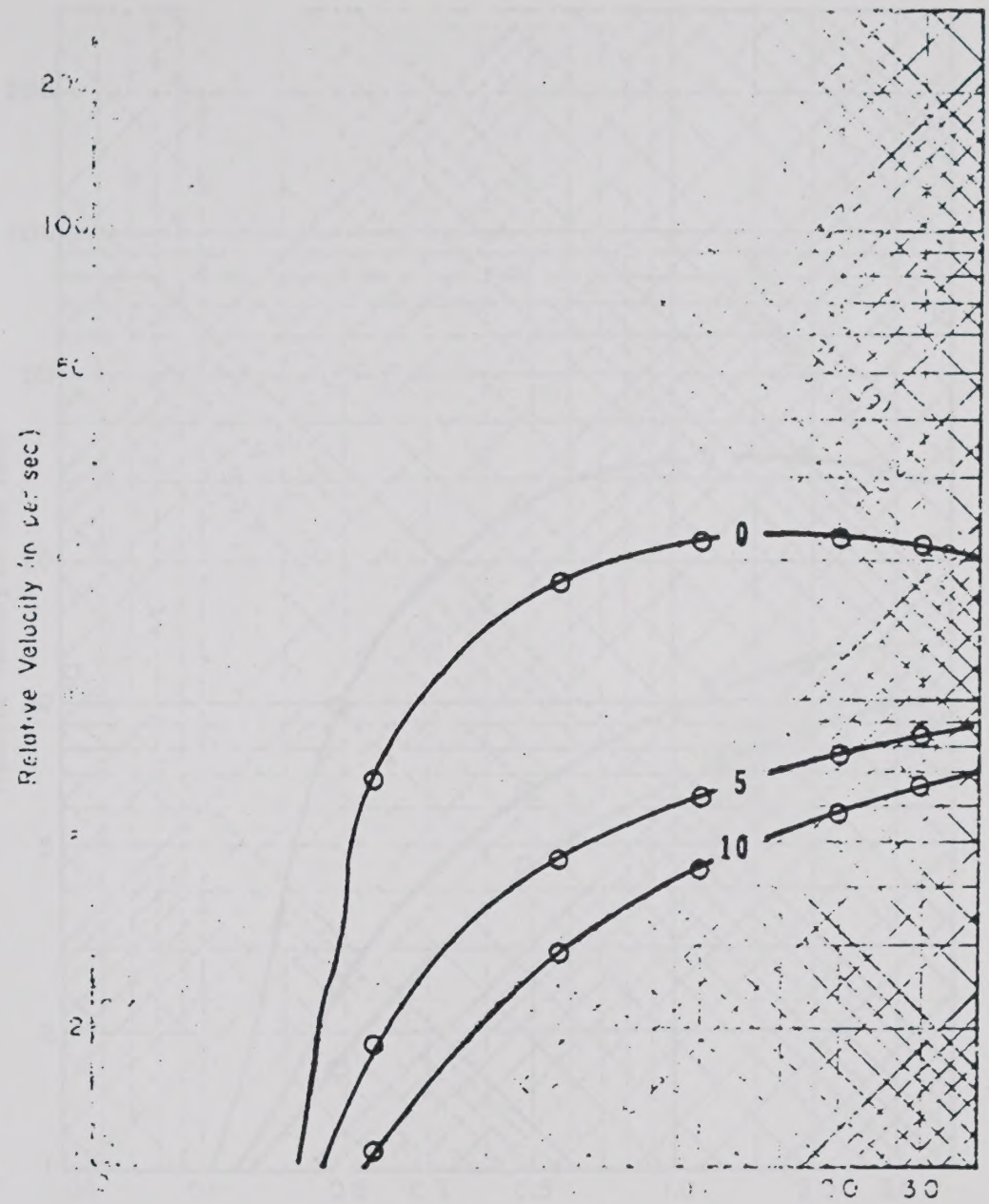


FIGURE 61. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Bedrock Sites (Zone S2)

GRAPHIC

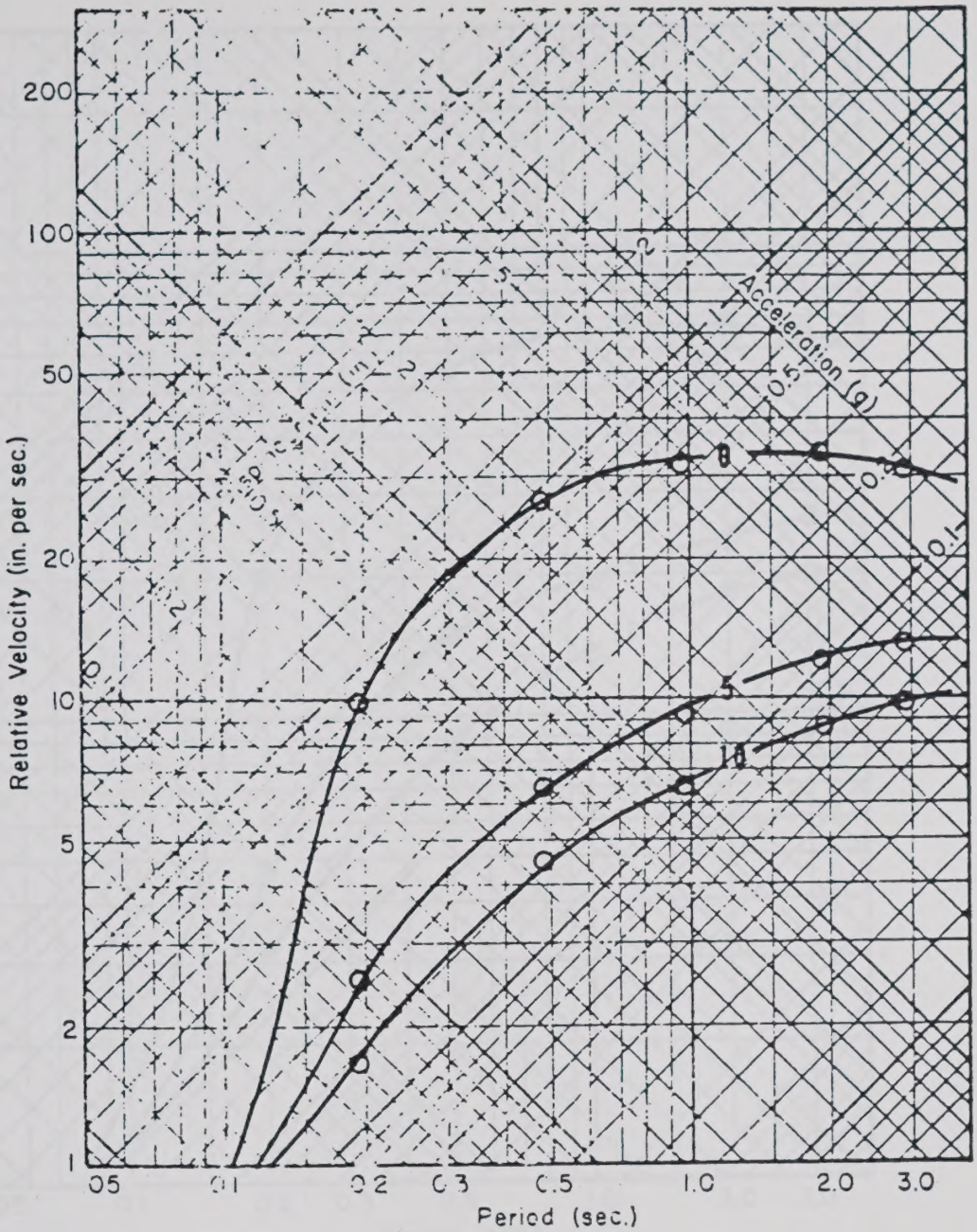


FIGURE 62. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Bedrock Sites (Zone S3)

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

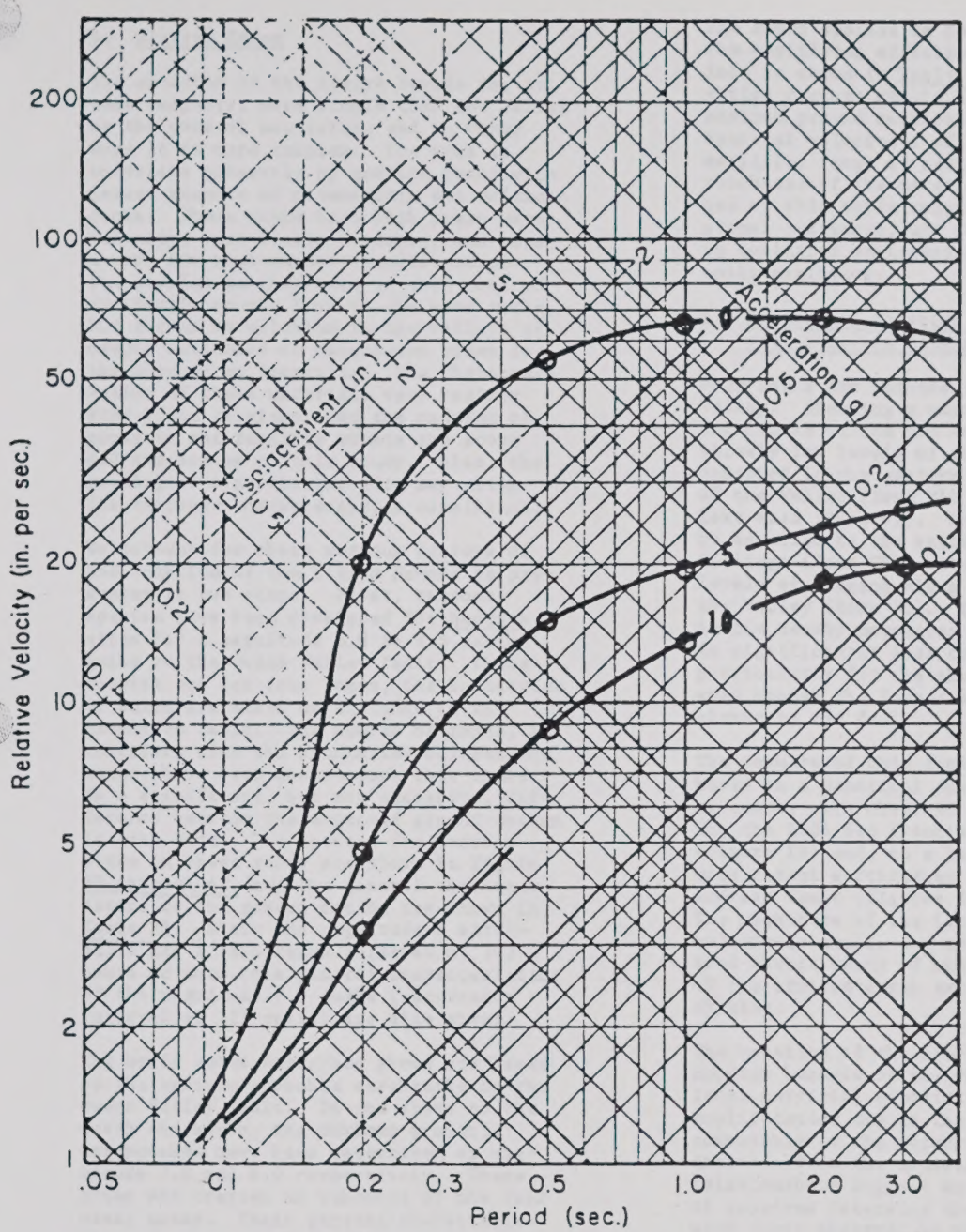


FIGURE 63. RESPONSE SPECTRUM, for 0, 5% and 10% of critical damping.

Bedrock Sites (Zone S4)

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

4. Sierran Zones

The zonation of the Sierra Nevada is, in some respects, more simple than the Valley or the coastal mountains, and in other ways it is more complex. The area is underlain primarily by granite rocks with lesser amounts of metamorphic and volcanic rocks. These rocks have high shear-wave velocity, very little layering, and thus a very low near-surface amplification. The problem in this area is that most of the people do not live on the hard rocks, but rather on alluvium in the valleys or deeply weathered or decomposed zones in the meadows or foothills. The characteristics of these materials vary rapidly from place to place, and the mapping of zones is not feasible within the scope and map scales of this study. Also, the grading of a particular site may alter its response characteristics considerably.

To account for these various factors of the zonation of the Sierra Nevada is presented in two steps. First, response spectra have been developed for bedrock sites for a magnitude 8.0 to 8.5 earthquake on the Owens Valley fault. These spectra are for four zones, the boundaries of which are based on distance to the causative fault. The number of zones, and therefore also the boundaries between the zones, have been chosen such that there is a significant, but not excessive, difference between the expected ground motion in each zone. The spectra for bedrock sites in these zones are shown in Figure 60 through 63, and the general characteristics of the ground motion are shown in Table 28. Since the magnitude 8 earthquake has a recurrence interval of 300 years or more, the general characteristics of the magnitude 7.0 quake (recurrence interval of 125 years) are also given.

The basic zones described above are based on the maximum probable earthquake on the Owens Valley fault. In the areas to the north and south, the maximum probable earthquakes have been determined as magnitude 7.0 and 6.0 respectively. These areas are treated as subzones of the four basic zones. Their general characteristics are shown in Table 28, and the distribution of the zones is shown on Plate I.

The above applies to bedrock sites only. The amplifying effects of surficial materials is shown in Table 29. The amplification factors should be applied to the maximum ground acceleration or the spectral velocities of the spectra for the amplified range of period depending on the thickness of the material present. The use of this table requires some professional judgement, and is intended for use by qualified engineering geologists or soils engineers.

5. Summary of Zonation and Comparison with Observed Intensity

Four zones are defined in the San Joaquin Valley. Assuming a magnitude 8.0 - 8.5 earthquake on the San Andreas fault, relatively low levels of shaking should be expected in the eastern and central parts of the Valley (Zone V1) and in the Tulare Lake area (Zone V2). Strong shaking should be expected in the western valleys near Coalinga (Zone V4), with the intermediate levels of shaking along the west side of the Valley (Zone V3). The ground motion in the nearby mountains (Zones C1 and C2) is significantly less than in Zone V4, particularly for the shorter periods, even though the former are generally closer to the fault.

The results of this zonation, which is based on a numerical analysis, is in good agreement with observed intensities during the 1906 San Francisco earthquake (Figure 19) and, to a lesser extent, with more recent earthquakes along the San Andreas fault (Figures 20 through 22). The magnitude of the latter have been relatively small, and they are not considered direct tests of the zonation because of the limited areal extent of strong shaking.

The zonation of the Sierra Nevada is more complex because of the variation due to local surficial deposits. The near-surface amplification due to these deposits is comparable to the attenuation due to distance from the causative fault. These relationships suggest an irregular pattern of expected intensity that is compatible with those observed in recent earthquakes (Figures 25 and 26).

The zonation is also generally compatible with intensities reported for the 1952 Arvin-Tehachapi earthquake (Figures 26 and 27) with the exception of the locally higher intensity along the west side of the Valley north of Coalinga. This area of higher intensity, compared to that of the east, would be expected from an earthquake originating to the west, but not from one originating on a fault located to the south. One explanation may be the rly compacted soils in this area.

TABLE 27
SUMMARY OF DISTANCE AND AMPLIFICATION FACTORS USED IN
COMPUTING GROUND-MOTION SPECTRA IN THE COASTAL MOUNTAINS

Area and Sites Used in Computing A_2	Distance		Near-Surface Amplification and Applicable Range of Period				
			Amplification A_2		Amplification Ratio A_2/A_1		
	d_2	d_1/d_2	Short Period	Long Period	Short Period	Int. Period	Long Period
Kettleman Trend (Site 14)	23 mi	0.435	3 (0-1.6 sec)	4 (1.6-4.0 sec)	1.16 (0-1.6 sec)	--	1.2 (1.6-4.0 sec)
Joaquin Ridge (est. from Site 14)	18 mi	0.556	3 (0-1.6 sec)	2.5 (1.6-4.0 sec)	0.5 (0-4.0 sec)	--	--
Jacalitos Trend (Site 14)	12 mi	0.83	3 (0-0.9 sec)	4 (0.9-4.0 sec)	0.5 (0-0.9 sec)	0.67 (0.9-1.6 sec)	0.8 (1.6-4.0 sec)
Wortham Valley (Site 14)	5 mi	2.0	3 (0-0.9 sec)	4 (0.9-4.0 sec)	0.5 (0-0.9 sec)	0.67 (0.9-1.6 sec)	0.8 (1.6-4.0 sec)

TABLE 28
SUMMARY OF GROUND-MOTION CHARACTERISTICS
SIERRAN ZONES ON BEDROCK

Zone	Recurrence Interval and Magnitude								
	300 years M=8.25			125 years M=7.0			135 years M=6.0		
	g	T	t	g	T	t	g	T	t
S1	0.03	0.3	20	0.01	0.25	10	--	--	--
S2	0.075	0.3	25	0.04	0.25	15	--	--	--
S3	0.13	0.35	30	0.09	0.3	15	--	--	--
S4	0.19	0.35	40	0.15	0.3	20	--	--	--
S2N	--	--	--	0.04	0.25	15	--	--	--
S3N	--	--	--	0.09	0.3	15	--	--	--
S4N	--	--	--	0.15	0.3	20	--	--	--
S2S	--	--	--	--	--	--	0.02	0.2	5
S3S	--	--	--	--	--	--	0.05	0.25	10
S4S	--	--	--	--	--	--	0.10	0.25	10

g = maximum ground acceleration as a fraction of gravity

T = predominant period in seconds

t = duration of "strong" shaking in seconds

S = Sierran Zone

TABLE 29
AMPLIFICATION OF BEDROCK MOTION
BY SURFICIAL MATERIALS

Material	S-Wave Velocity	Amplification Factor	Approximate Thickness for Amplified Period of: 0-0.1s	0-0.2s	0-0.3s	0-0.5s
Deep Weathering	2500 - 5000'/sec.	1.5	50'	150'	--	--
Decomposed Granite	1000 - 2500'/sec.	3	30'	75'	150'	--
Alluvium	500 - 2000'/sec.	4	15'	40'	70'	140'
Compacted Fill	800 - 900'/sec.	4-5	20'	45'	75'	--

Intensity is based primarily on damage which can occur for reasons other than strong shaking. In this case, the damage may be as much related to the poor foundation conditions as it is to the level of ground shaking.

6. Relationship Between Shaking Characteristics and the Uniform Building Code

The relationships between the microzones as developed herein and the seismic design forces for the standard zones of the 1973 Uniform Building Code are shown in Table 30. This subject is developed further in the Policy Reports for the five counties, and is included here for reference purposes only.

D. SECONDARY HAZARDS

1. Settlement

Settlement may occur in poorly consolidated soils during earthquake shaking as the result of a more efficient rearrangement of the individual grains. Settlements of sufficient magnitude to cause significant structural damage are normally associated with rapidly deposited alluvial soils, or improperly founded or poorly compacted fills.

Plate I shows two major zones of "active settlement" and delineates a relatively large area, on the west side of the valley, of soils which are susceptible to settlement. The zones of "active settlement" are known to undergo extensive settling with the addition of irrigation water, but evidence for settlement due to ground shaking is not available. Since the process of more efficiently rearranging the soil grains is nearly the same whether it is initiated by the addition of water or by vibration, the potential for settlement of these soils by ground shaking must be considered.

The only urban area directly affected by these collapsible soils is the City of Coalinga. While no evidence of settling was reported in this area for the 1906 earthquake on the San Andreas fault zone, fluctuating groundwater levels may have changed the local soil characteristics. There is not sufficient subsurface data (in terms of laboratory testing) to categorically state that settlement will occur during a large earthquake, however, the data are sufficient to indicate that the potential is present.

2. Liquefaction

Liquefaction involves a sudden loss in strength of a saturated, cohesionless soil (predominantly sand) which is caused by shock or strain, such as an earthquake, and results in temporary transformation of the soil to a fluid mass. If the liquefying layer is near the surface the effects are much like that of quicksand on any structure located on it. If the layer is in the subsurface, it may provide a sliding surface for the material above it. Liquefaction typically occurs in areas where the groundwater is less than 30 feet from the surface, and where the soils are composed predominantly of poorly consolidated fine sand.

Zones within the Five-County study area where the groundwater is less than 30 feet from the surface are delineated on Plate I. Subsurface information from these zones however, indicate that the soil types are not conducive to liquefaction; they either contain too much clay (on the westerly side of the San Joaquin Valley) or are of too coarse a texture (as on the east side). Further, the maximum ground surface accelerations from the expected earthquakes are too low on the east side of the Valley to produce the shock necessary to initiate liquefaction.

Figure 64 presents graphs showing the potential for liquefaction for earthquakes with magnitudes 6.5-7.0 and 8.0-8.5. These graphs, derived from Seed and Idriss (1971) indicate that the ground acceleration must approach 0.3g before liquefaction could be anticipated in a fine, sandy soil with the relative densities typical of the San Joaquin Valley alluvial deposits (65%-75%). However, as discussed above, the available subsurface data indicate soil types mitigating against the occurrence of liquefaction.

3. Landslides

a. Types of Landslides

Landslides represent only one step in the continuous, natural erosional process. They demonstrate in a dramatic way the tendency of natural processes to seek a condition of equilibrium. The steep slopes of mountainous and hillside terrain are not in a state of equilibrium, and various erosional processes act on them to gradually reduce them to near sea level. Landsliding is an important agent in this cycle.

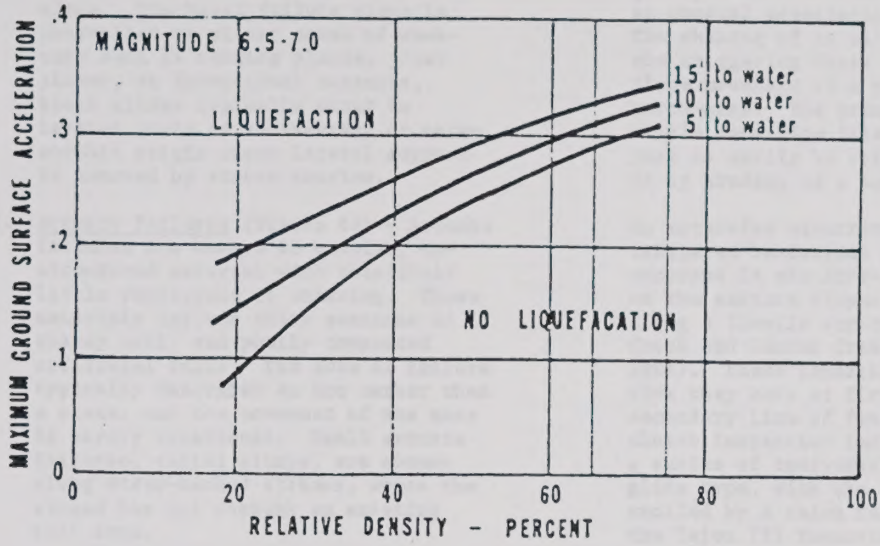
TABLE 30
UNIFORM BUILDING CODE SEISMIC ZONE AND DESIGN FORCE MULTIPLICATION FACTOR

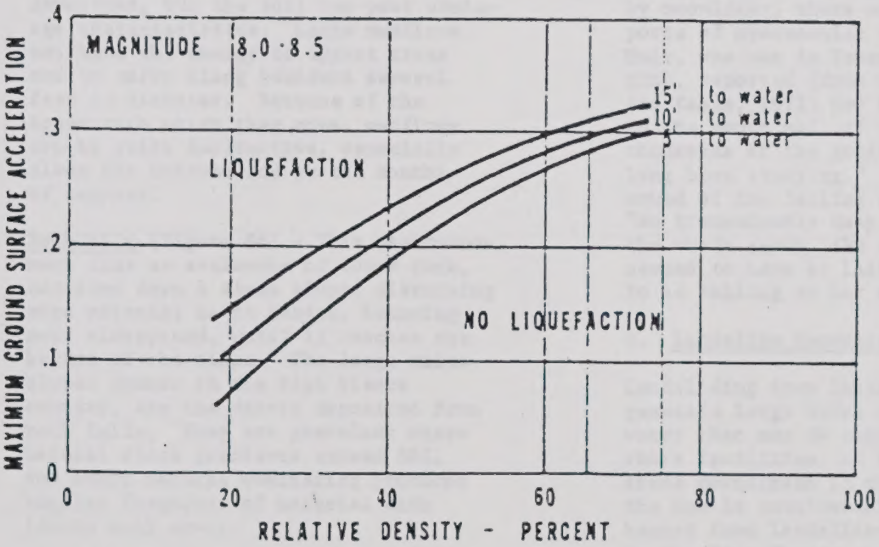
	NORMAL FACILITIES				CRITICAL FACILITIES			
Microzone	Earthquakes (Magnitude)	Source Fault	Recurrence (years)	UBC (Zone)	Earthquakes (Magnitude)	Source Fault	Recurrence (years)	UBC (Zone)
V 1	8.0-8.5	San Andreas	100-150	II	8.0-8.5	San Andreas	100-150	II x 2
V 2	8.0-8.5	San Andreas	100-150	II	8.0-8.5	San Andreas	100-150	II x 2
V 3	8.0-8.5	San Andreas	100-150	III	8.0-8.5	San Andreas	100-150	III x 1.5
V 4	8.0-8.5	San Andreas	100-150	III	8.0-8.5	San Andreas	100-150	III x 2
C 1	8.0-8.5	San Andreas	100-150	III	8.0-8.5	San Andreas	100-150	III x 1.5
C 2	8.0-8.5	San Andreas	100-150	III	8.0-8.5	San Andreas	100-150	II X 2
S 1	7.0	Owens Valley	125	II	8.25	Owens Valley	300-10,000	II x 2
S 2	7.0	Owens Valley	125	III	8.25	Owens Valley	300-10,000	III x 1.5
S 3	7.0	Owens Valley	125	III	8.25	Owens Valley*	300-10,000	III x 1.5
S 4	7.0	Owens Valley	125	III	8.25	Owens Valley	300-10,000	III x 2
S 2 N	7.0	Owens Valley	125	II	7.0	Owens Valley	125	II x 2
S 3 N	7.0	Owens Valley	125	III	7.0	Owens Valley	125	III x 1.5
S 4 N	7.0	Owens Valley	125	III	7.0	Owens Valley	125	III x 1.5
S 2 S	6.0	Owens Valley	135	III	6.0	Owens Valley	135	III x 1.5
S 3 S	6.0	Owens Valley	135	III	6.0	Owens Valley	135	III x 1.5
S 4 S	6.0	Owens Valley	135	III	6.0	Owens Valley	135	III x 1.5

*Configuration of the S-3 Zone in extreme southern Tulare County is modified slightly for expected earthquakes from the White Wolf fault.

FIGURE 64

Liquefaction potential for earthquakes of magnitude 6.5 - 7.0 (top) and 8.0 - 8.5 (bottom)





GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

SOURCE: ENVICOM

Several types of landslides commonly encountered include:

1. Block glides (Figure 65) - These are the largest, most impressive type of slide. The basal failure plane is controlled by planar zones of weakness such as bedding planes, joint planes, or formational contacts. Block glides typically occur in layered rocks of sedimentary or metamorphic origin where lateral support is removed by stream erosion.

2. Arcuate failures (Figure 66) - Arcuate failures are common in massive, unstructured material with relatively little resistance to shearing. These materials include thick sections of clayey soil, and poorly compacted artificial fills. The zone of failure typically describes an arc rather than a plane, and the movement of the mass is partly rotational. Small arcuate failures, called slumps, are common along steep-banked streams, where the stream has cut through an existing soil zone.

3. Mudflows (Figure 67) - Mudflows involve very rapid downslope movement of saturated soil, sub-soil, and weathered bedrock. They originate in hillside areas where the soil horizon is well developed, but the soil has poor drainage characteristics. Large mudflows may have the energy to uproot trees and to carry along boulders several feet in diameter. Because of the speed with which they move, mudflows can be quite destructive, especially along the bottoms and at the mouths of canyons.

4. Rockfalls (Figure 68) - This phenomenon, much like an avalanche of loose rock, cascades down a steep slope, disturbing more material as it passes, becoming more widespread, until it reaches the bottom of the slope. The large talus slopes common in the High Sierra country, are the debris deposited from rock falls. They are prevelant where natural slope gradients exceed 50%, and where natural weathering produces angular fragments of material with little soil cover.

b. Relationships of Earthquakes to Landslides

Landslides should be considered a basic geologic hazard rather than one having an unusual association with earthquakes. The shaking of an earthquake only provides the triggering force to initiate downslope movement of a previously unstable earth-mass. The prime factor is the unstable condition itself. Movement could just as easily be triggered by heavy rains, or by grading on a construction project.

An extensive occurrence of seismically triggered landslides was reported to have occurred in the Five-County area in 1906 on the eastern slopes of the coast ranges along a 23-mile stretch between Panoche Creek and Cantua Creek (Lawson et al, 1908). These landslides were so extensive they were at first thought to be a secondary line of faulting. However, closer inspection indicated that they were a series of individual slides of the block glide type, with the alignment being controlled by a thick reddish-brown shale in the Tejon (?) Formation.

Rock falls were reported in the Sierra Nevada as the result of the 1872 earthquake in Owens Valley. Even though this earthquake occurred at night with observation limited to that which one could see by moonlight, there were a number of reports of spectacular rock falls. John Muir, who was in Yosemite Valley at the time, reported (from Oakshott, Greensfelder and Kahle, 1972) how he watched Eagle Rock on the south wall of the valley, fall "in thousands of the great boulders I had so long been studying." He described the sound of the falling or sliding talus as "so tremendously deep and broad and earnest, the whole earth like a living creature seemed to have at last found a voice and to be calling to her sister planets."

c. Landslide Generated Water Waves

Landsliding into lakes or reservoirs may generate large waves on the surface of the water that may do considerable damage to shore facilities, to the dam itself, or to areas downstream if the volume overtopping the dam is considerable. The potential hazard from landslide-induced water waves in the Five-County area is, therefore, related to the presence of unstable land masses on the slopes adjoining reservoirs or lakes. This possibility was checked carefully as a part of the study of aerial photographs for landslides in the area, and the results are included with the discussion of that subject.

d. Geologic Setting

The Five-County area can be divided into three distinct landslide environments: the Coast Ranges on the west, the Central Valley, and the Sierra Nevada on the east. These three divisions are geologically dissimilar and present different stability situations.

The Coast Ranges in the study area, are underlain by moderately folded sedimentary rocks of various ages ranging from Cretaceous to Quaternary. The terrain is controlled to a large extent by the geologic structure with many natural slopes parallel with the underlying bedding. Large block-glide failures occur in the Coast Ranges where stream erosion has removed support along the bedding planes.

Complexly folded and fractured metamorphic rocks of the Franciscan Group are also present in a portion of the Coast Ranges within the study area. Failures within these rocks are common, and are usually controlled by fracture patterns, cleavage planes, and sheared zones.

The Central Valley, underlain by material shed from the adjacent mountains, is basically a broad feature-less alluvial plain. The virtual absence of terrain mitigates against the occurrence of large-scale landsliding, but small slumps may be common along the banks of incised stream courses.

The Sierra Nevada comprises approximately one-third of the study area. The range is essentially a homogeneous blend of several types of granitic rocks in which many islands of older metamorphic rocks occur.

The granitic rocks are generally less-prone to landsliding than other types of rock because of their homogeneous nature and their relatively stable chemical properties. However, where the granite has been subjected to faulting, or fracturing, it too may fail along planes of weakness.

Many of the metamorphic rocks within the Sierra Nevada are complexly folded and fractured. As with similar rocks across the valley, these are prone to landslides controlled by the fracture patterns, cleavage planes, and sheared zones.

Steep slopes within the Sierra Nevada are subject to local rock-falls where an adequate soil cover in not established.

e. Landslide Risk Appraisal

1. Methodology

The appraisal of landslide risks in the Five-County area takes into account various geologic criteria, such as composition, structure, degree of folding and fracturing, and geomorphic characteristics such as terrain, direction of natural slope, etc., which combine to form situations of varying stability. These characteristics were analyzed by stereoscopically studying aerial photographs and reviewing pertinent literature. Particular attention was paid to areas adjacent to population centers, major highways through mountainous terrain, major reservoirs, and areas of encroaching urbanization.

The appraisal of slope stability is presented in terms of four levels of risk: 1) No risk, 2) Low risk, 3) Moderate risk, and 4) High risk. The final results are graphically detailed on Plate I and are discussed briefly below.

2. Risk Categories

The areas delineated as having "No risk" of landslides (category 1 on Plate I) are comprised chiefly of flatlands, valley bottoms, and areas of minimal topographic relief.

Areas assigned a "Low risk" rating (category 2 on Plate I) include hillside and mountainous terrain of competent igneous and metamorphic rocks and sedimentary rocks with favorable bedding and composition. This category encompasses much of the Sierra Nevada range, but is assigned only to local zones in the coast ranges. The "Low risk" category, as delineated on Plate I, indicates areas in a relatively stable situation in terms of landslide potential.

Those areas designated as having a "Moderate risk" of landsliding (category 3 on Plate I) include much of the Coast Ranges on the west side of the area, and several zones along the western flanks of the Sierra Nevada. The "Moderate risk" category is assigned where geologic and geomorphic characteristics have combined to produce only "semi-stable" situations. These situations include dip slopes (natural slopes parallel to bedding in sedimentary rocks), complexly folded metamorphic rocks, and zones of fractured rock.

The "High risk" areas (category 4 on Plate I) include a significant portion of the coast ranges along the west side of the area, as well as several areas within the Sierra Nevada. This designation is assigned to areas of weak rock prone to landsliding, and to existing landslides.

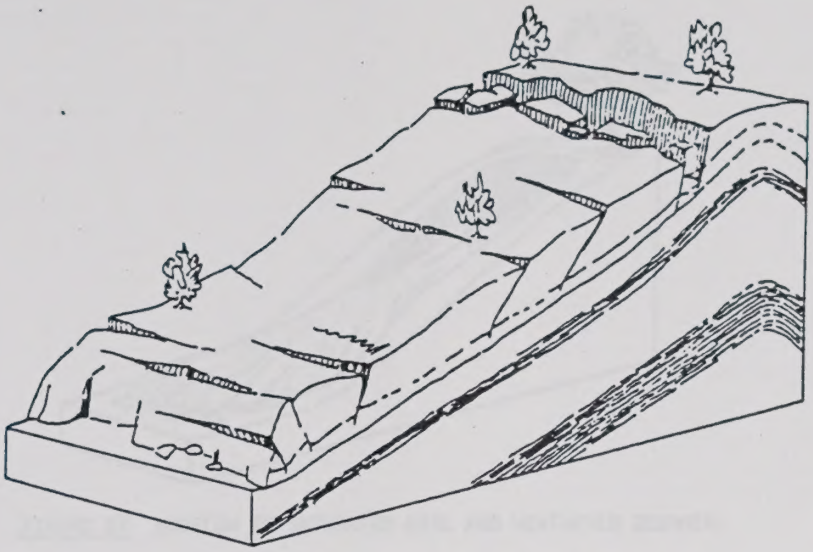


FIGURE 65 BLOCK GLIDE LANDSLIDE WHICH HAS FAILED ALONG AN UNSUPPORTED BEDDING PLANE.

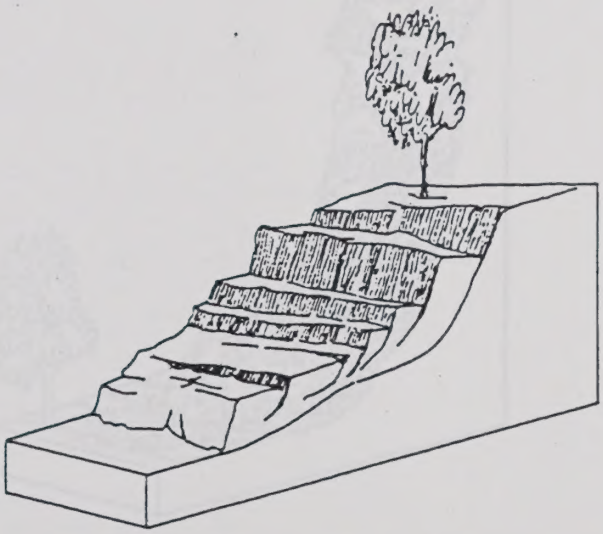


FIGURE 66 SLUMP OCCURRING IN AN UNSTRUCTURED SOIL ALONG AN ARCUATE FAILURE PATH.

FIGURE 66 FROM U. S. GEOLOGICAL SURVEY, MF 493

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

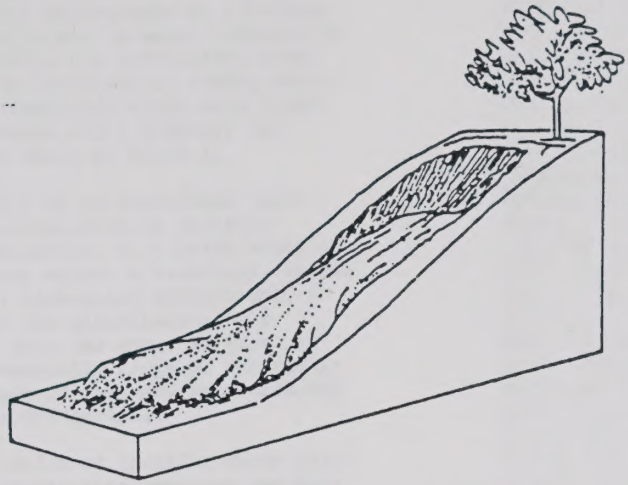


FIGURE 67 MUDFLOW OF SATURATED SOIL AND WEATHERED BEDROCK.

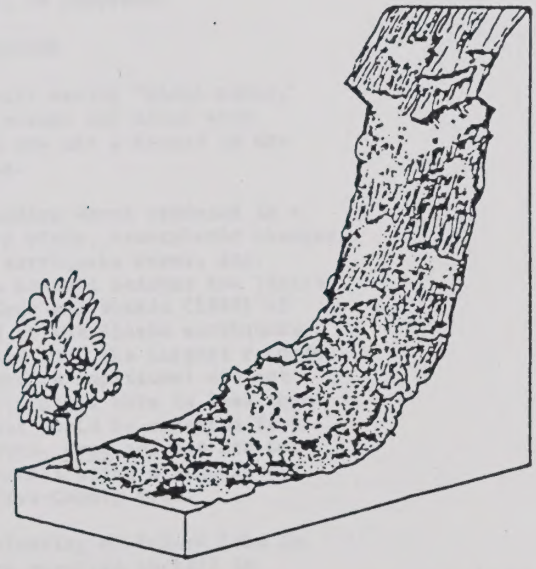


FIGURE 68 ROCKFALL INVOLVING A CASCADE OF WEATHERED BEDROCK DOWN A STEEP SLOPE.

FIGURES 67 & 68 FROM U. S. GEOLOGICAL SURVEY, MF 493

GRAPHICS BY TULARE COUNTY PLANNING DEPARTMENT

f. Summary of Landslide Hazards

No existing landslides were identified, from the aerial photographs or pertinent literature, adjacent to major highways or reservoirs within the Five-County area. However, areas appraised as having moderate and high landslide risks were found to adjoin several major highways and reservoirs as shown on Plate I.

The possibility of an underwater landslide, originating from an unstable deltaic accumulation, at a point where a stream or river enters a reservoir, cannot be completely discounted because only a small part of the accumulations are visible even from the air. However, no evidence of unusually large or apparently unstable masses of sediment were observed on the aerial photographs.

Further evaluation of specific sites within the Five-County area requires geologic and engineering data normally available only during the course of a detailed investigation of the site as well as knowledge of any modification of terrain that may be proposed for the site. This evaluation is best accomplished at the time a specific project is proposed.

E. TSUNAMIS AND SEICHES

Tsunamis, commonly called "tidal waves," are limited to oceans and areas with coastlines, and are not a hazard in the Five-County area.

Seiches are standing waves produced in a body of water by winds, atmospheric changes, the passage of earthquake waves, etc. Studies of true seismic seiches are limited, but that by McGarr and Vorhis (1968) of seiches induced by the Alaska earthquake of 1964 indicates that the largest recorded wave heights (double amplitude) did not exceed 1.2 feet. Since this is less than wave heights that would be expected from wind-induced waves, true seiches are not considered as constituting a significant hazard in the Five-County area.

A seiche-like sloshing of Tulare Lake is reported to have occurred in 1857 in response to seismic waves that accompanied the great Fort Tejon earthquake of that year (California Geology, August, 1972). The lake was very large, about 100 miles by 30 miles, and runup was reportedly as much as 3 miles. In this instance, the large area of inundation has been attributed to the low topographic relief, and had the lake been confined by levees or steeper banks the effects would have been minimal. It should also be noted that the hazard from such seismically induced inundation is not significantly different than the flood hazard in the same area, and the risk of occurrence is considerably less.

It should be noted, however, that considerable confusion exists as to the application of the term seiche. The definition included herein (see Appendix), limits a true seismic seiche to standing waves set-up by the passage of seismic waves from an earthquake. Traveling waves set-up by landsliding into or within a lake or reservoir, or those induced by the tilting of the water body, are not true seismic seiches. Dramatic examples of damage attributed at least in part to seiching at Hebgen Lake in Montana in 1959 (Christopherson, 1962) or at Kenai Lake in Alaska in 1964 (McCulloch, 1966) are more likely the results of traveling waves (or reflected traveling waves) set-up by landsliding or the tilting of the reservoir bottom. Significant tilting of major reservoirs or lakes is not expected in the Five-County area, and potential hazard from landslide-induced waves has been discussed previously under Landslides.

III CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

General

1. This report comprises the technical component of the Five County (Tulare, Fresno, Kings, Madera, and Mariposa) Seismic Safety Element. The conclusions and recommendations from this report are to be carried forward and expanded in a policy (component) report.

2. This study has been prepared in accordance with Section 65302 (f) of the Government Code which requires a Seismic Safety Element and along guidelines set forth by the California Council on Intergovernmental Relations dated September 20, 1973.

Active Faulting

1. No active faults are known within the Five-County area. Two relatively small faults may be present in south-central Tulare County that cut Pliocene and early Pleistocene rocks, but not the later Pleistocene or Recent materials. These relationships indicate that the faults have not moved in at least 100,000 years, and should not be considered a significant hazard.

2. Although geographically outside the study area, the San Andreas Fault and the Owens Valley Fault Group are considered the two principal sources of damaging earthquakes for the Five-County area.

Ground Shaking

1. The principal earthquake hazard effecting the Five-County area is ground shaking.

2. Known active faults that pose a serious hazard to the Five-County area as being the source of strong ground shaking include the San Andreas fault just west of the area, the Owens Valley fault group to the east, and possibly the White Wolf fault to the south. Analysis of available data on the seismicity, accumulating crustal strain, and rates of geologic slip yield intervals for recurrence of the maximum probable earthquake from these faults are as follows:

Fault and Segment	Magnitude of Maximum Probable Earthquake (Richter)	Recurrence Interval (years)
San Andreas fault:		
1857 Break	8.3-8.5	102-155
Transition zone	8.1-8.3	102-155
Active area	7.0	100
Owens Valley fault group:		
North area	7.0	125
Central area	8.25	300-10,000
South area	6.0	135
White Wolf fault	7.0	1,000-5,000

3. Based on the above earthquakes as sources of shaking and near-surface amplification determined from computer analysis of multi-layer models, the San Joaquin Valley area has been divided into four zones, the coastal mountains into two zones, and the Sierra Nevada into four basic zones.

4. Response spectra have been derived for the maximum probable earthquake in each zone, and the general characteristics determined for all the relevant earthquakes in each zone. These characteristics indicate that the requirements of the Uniform Building Code for Zone II will be adequate for the more populous parts of the Five-County area. Exceptions are the western San Joaquin Valley and coastal mountains, and the more easterly parts of the Sierra Nevada, particularly the alluvial valleys.

5. Comparison of the seismic zonation, developed by mathematical analysis, with the distribution of shaking intensity (isoseismal maps) for the more important historical earthquakes indicates good agreement.

6. The relationships between the seismic microzones and the seismic design forces for the standard zones of the 1973 Uniform Building Code are as follows:

Uniform Building Code Seismic Zone
and Design Force Multiplication Factor

Microzone	Normal Facilities	Critical Facilities
V 1	II	II x 2
V 2	II	II x 2
V 3	III	III x 1.5
V 4	III	III x 2
C 1	III	III x 1.5
C 2	III	III x 2
S 1	II	II x 2
S 2	III	III x 1.5
S 3	III	III x 1.5
S 4	III	III x 2

Secondary Hazards

1. Secondary seismic hazards in the Five-County area are considered to be minimal. Significant geological problems do exist, however, and are worthy of further investigation on a subregional or site-by-site basis.

2. Two major zones of "active settlement" in the west San Joaquin Valley are delineated on Plate I. These zones of active settlement are known to undergo extensive settling with the addition of irrigation water, but evidence for settlement due to ground shaking is not available.

3. The area with the greatest potential for liquefaction is the west side of the San Joaquin Valley (Plate I). Studies by the Department of Water Resources for the California Aqueduct indicate that the clay content of the poorly consolidated sediments is sufficiently high to prevent liquefaction.

4. General subsidence due to groundwater withdrawal and differential subsidence due to hydro-compaction are problems in the area of poorly consolidated sediments on the west side of the San Joaquin Valley (Plate I). This condition constitutes a geologic hazard worth of further investigation, but is not considered a seismic hazard.

5. Slope stability (landslides, mud flows, etc.) has been evaluated in terms of four levels of risk and graphically detailed on Plate I.

6. Tsunamis are not a secondary hazard in the Five-County area.

7. Seiches are not considered as constituting a significant hazard in the Five-County area.

B. RECOMMENDATIONS

Active Faulting

1. Further investigation of the two small faults in south-central Tulare County should be deferred until such time as development along or adjacent (within 0.25 mi) to them may be proposed.

Ground Shaking

1. Revision or modification of county and city building codes should be considered in those zones in which shaking is expected to exceed levels covered by existing codes.

2. Response spectra are included for use in the design of new, or the evaluation of existing major or critical facilities.

Secondary Hazards

1. The problem of hydrocompaction of the poorly consolidated sediments on the west side of the San Joaquin Valley may deserve additional study depending on land-use trends in this area. This should be considered a general geologic hazard rather than restricted to association with a major seismic event.

2. Other geologic hazards, such as landslides, potentially unstable slopes, local groundwater conditions, etc., are present particularly in the mountain and foothill terrains. Adequate evaluation of these problems normally requires detailed engineering geologic and soils engineering investigations that are economically feasible only on a project basis.

3. Chapter 70 of the Uniform Building Code should be adopted and enforced. To insure this entities involved should retain, on a full or part-time basis, a qualified engineering geologist to review the necessary reports. This procedure will be particularly important as urban development expands into the foothills and recreational development occurs in the mountains.

C. ADDITIONAL STUDIES

The review and analysis of available data, particularly that on secondary or geologic hazards, indicate that additional studies may be advisable in areas of expanding urbanization of more intensive rural use. Topics of studies that should be considered are as follows:

1. Hydrocompaction and collapsible soils. Detailed studies have been conducted along some major engineering works (Interstate 5, California Aqueduct, etc.), but the limits of the affected area is based on an interpretation of existing geologic mapping. Additional testing and analysis is advisable, particularly in the Kettlemen Plain and the expanding agricultural areas near Interstate 5.

2. Slope stability and other environmental geologic problems in the Sierran foothills. Basic information in categories such as landslide distribution, perched groundwater, sewage effluent capacity, erosion potential, etc., will be required to adequately administer public safety in areas of expanding urbanization or recreational development. This information should be developed at a scale larger (i.e. more detailed) than that of this investigation.

3. Rising perched groundwater. Increased irrigation, in response to more available water and worldwide agricultural needs, may result in perched groundwater rising to, or near, the surface in some areas along the west side of the San Joaquin Valley. Such a condition could not only result in problems related to continued agricultural use, but also the stability of structures, roads, etc., and liquefaction or settlement.

4. Lakes and reservoirs. A further analysis of lakes and reservoirs that involve human habitation along the shore or in the near-downstream should be considered. Such an analysis should consider not only seismically generated waves, but also the effects of wind-generated waves and landslides on shoreline erosion, bluff stability, etc. The scale of mapping should be larger than that used in this investigation.

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APPENDIX

GLOSSARY OF TERMS

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GLOSSARY OF TERMS

ACTIVE FAULT - One that has moved in recent geologic time and which is likely to move again in the relatively near future. Definitions for planning purposes extend on the order of 10,000 years or more back and 100 years or more forward.

ALLUVIAL - Pertaining to or composed of alluvium, or deposited by a stream or running water. (AGI, 1972)

ALLUVIUM - A general term for clay, silt, sand, gravel or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope. (AGI, 1972)

AMPLIFICATION - Elaboration; augmentation; addition (Webster). As used herein, near-surface amplification is the augmentation of wave amplitude resulting from the change in physical properties in near-surface layers (See Introduction).

AMPLITUDE - The extent of the swing of a vibrating body on each side of the mean position. (Webster).

BLOCK GLIDE - A translational landslide in which the slide mass remains essentially intact, moving outward and downward as a unit, most often along a pre-existing plane of weakness such as bedding, foliation, joints, faults, etc. (AGI, 1972)

COHESION - Shear strength in a sediment not related to interparticle friction. (AGI, 1972)

COLLUVIUM - (a) A general term applied to any loose, heterogenous, and incoherent mass of soil, material or rock fragments deposited chiefly by mass-wasting, usually at the base of a steep slope or cliff. (b) Alluvium deposited by unconcentrated surface runoff or sheet erosion, usually at the base of a slope (AGI, 1972)

COMPACTION - Reduction in bulk volume or thickness of, or the pore space within, a body of fine-grained sediments in response to the increasing weight of overlying material that is continually being deposited, or to the pressure resulting from earth movements within the crust. It is expressed as a decrease in porosity brought about by a tighter packing of the sediment particles. (AGI, 1972)

CONSOLIDATED MATERIAL - Soil or rocks that have become firm as a result of compaction.

DAMPING - The resistance to vibration that causes a decay of motion with time or distance, e.g. the diminishing amplitude of an oscillation. (AGI, 1972)

DIFFERENTIAL SETTLEMENT - Nonuniform settlement; the uneven lowering of different parts of an engineering structure, often resulting in damage to the structure. (AGI, 1972)

DISPLACEMENT (GEOLOGICAL) - The relative movement of the two sides of a fault, measured in any chosen direction; also, the specific amount of such movement. Displacement in an apparently lateral direction includes strike-slip and strike separation; displacement in an apparently vertical direction includes dip-slip and dip separation. (AGI, 1972)

DISPLACEMENT (ENGINEERING) - The geometrical relation between the position of a moving object at any time and its original position. (Webster)

EPICENTER - That point on the Earth's surface which is directly above the focus of an earthquake. (AGI, 1972)

FAULT - A surface or zone of rock fracture along which there has been displacement, from a few centimeters to a few kilometers in scale. (AGI, 1972)

FAULT SURFACE - In a fault, the surface along which displacement has occurred. (AGI, 1972)

FAULT SYSTEM - Two or more interconnecting fault sets. (AGI, 1972)

FAULT ZONE - A fault zone is expressed as a zone of numerous small fractures or of breccia or fault gouge. A fault zone may be as wide as hundreds of meters. (AGI, 1972)

FOCUS (SEISM) - That point within the Earth which is the center of an earthquake and the origin of its elastic waves. Syn: hypocenter; seismic focus; centrum (See Introduction) (AGI, 1972)

GROUND RESPONSE - A general term referring to the response of earth materials to the passage of earthquake vibration. It may be expressed in general terms (maximum acceleration, dominant period, etc.), or as a ground-motion spectrum.

HYPOCENTER - See focus.

INTENSITY (earthquake) - A measure of the effects of an earthquake at a particular place on humans and/or structures. The intensity at a point depends not only upon the strength of the earthquake, or the earthquake magnitude, but also upon the distance from the point to the epicenter and the local geology at the point. (AGI, 1972)

ISOSEISMAL LINE - A line connecting points on the Earth's surface at which earthquake intensity is the same. It is usually a closed curve around the epicenter. Syn: isoseismic line; isoseismal. (AGI, 1972)

LIQUEFACTION - A sudden large decrease in the shearing resistance of a cohesionless soil, caused by a collapse of the structure by shock or strain, and associated with a sudden but temporary increase of the pore fluid pressure. (AGI, 1972)

MACROSEISMIC DATA - Used herein to describe instrumentally recorded earthquakes generally in the range of Richter magnitude 3.0 or more. (This use differs from the AGI definition of "macroseismic observations.")

MAGNITUDE (earthquake) - A measure of the strength of an earthquake or the strain energy released by it, as determined by seismographic observations. As defined by Richter, it is the logarithm, to the base 10, of the amplitude in microns of the largest trace deflection that would be observed on a standard torsion seismograph (static magnification = 2800; period = 0.8 sec; damping constant = 0.8) at a distance of 100 kilometers from the epicenter. (AGI, 1972)

MICROSEISMIC DATA - Used herein to describe instrumentally recorded earthquakes generally in the range of Richter magnitude 3.0 or less. (This use is consistent with the AGI definition of microseism and microseismometer, but is more restricted than their definition of microseismic data.)

NATURAL PERIOD - The period at which maximum response of a system occurs. The inverse of resonant frequency.

NORMAL FAULT - A fault in which the hanging wall appears to have moved downward relative to the footwall. The angle of the fault is usually 45-90 degrees. There is dip-separation, but there may or may not be dip-slip. (AGI, 1972)

PREDOMINANT PERIOD - The period of the acceleration, velocity or displacement which predominates in a complex vibratory motion. In the analysis of earthquake vibrations, predominant period is normally the period of the maximum amplitude of the acceleration spectrum.

RESPONSE SPECTRUM - An array of the response characteristics of a structure or structures ordered according to period or frequency. The structures are normally single-degree-of-freedom oscillators, and the characteristics may be displacement, velocity or acceleration (see Introduction).

SEICHE - All standing waves on any body of water whose period is determined by resonant characteristics of the containing basin as controlled by its physical dimensions. (U.S. Geol. Survey Prof. Paper 544-E)

SEISMIC SEICHE - Standing waves set up on rivers, reservoirs, ponds and lakes at the time of passage of seismic waves from an earthquake. (U.S. Geol. Survey Prof. Paper 544-E)

SHEAR - A strain resulting from stresses that cause or tend to cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact; specifically, the ratio of the relative displacement of these parts to the distance between them. (AGI, 1972)

SHEAR WAVE OR S-WAVE - That type of seismic body wave which is propagated by a shearing motion of material so that there is oscillation perpendicular to the direction of propagation. It does not travel through liquids. (AGI, 1972)

SLIP - On a fault, the actual relative displacement along the fault plane of two formerly adjacent points on either side of the fault. Slip is three dimensional, whereas separation is two dimensional. (AGI, 1972)

STRIKE-SLIP FAULT - A fault, the actual movement of which is parallel to the strike (trend) of the fault. (AGI, 1972)

SUBSIDENCE - A local mass movement that involves principally the gradual downward settling or sinking of the solid Earth's surface with little or no horizontal motion and that does not occur along a free surface (not the result of a landslide or failure of a slope). (AGI, 1972)

TECTONIC - Of or pertaining to the forces involved in, or the resulting structures or features of the upper part of the Earth's crust. (mod. from AGI, 1972)

TSUNAMI - A gravitational sea wave produced by any large-scale, short-duration disturbance of the ocean floor, principally by a shallow submarine earthquake, but also by submarine earth movement, subsidence, or volcanic eruption, characterized by great speed of propagation (up to 950 km/hr.), long wavelength (up to 200 km.), long period (5 min. to a few hours, generally 10 - 60 min.), and low observable amplitude on the open sea, although it may pile up to great heights (30 m. or more) and cause considerable damage on entering shallow water along an exposed coast, often thousands of kilometers from the source. (AGI, 1972)

UNCONSOLIDATED MATERIAL - A sediment that is loosely arranged or unstratified or whose particles are not cemented together, occurring either at the surface or at depth. (AGI, 1972)

WATER TABLE - The surface between the zone of saturation and the zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere. (AGI, 1972)